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SURGERY

GYNECOLOGY AND OBSTETRICS

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NUMBER 1

THE TREATMENT OF WAR FRACTURES OF THE FEMUR

Professor SERGE S. YUDIN, M.D., Colonel Red Army M.C., Hon. F.A.C.S.
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TWO years of the present war have sufficiently proved the merits, disadvantages, and practicability of various methods of the treatment of compound war fractures of the extremities. The conclusion is clear and definite and may be formulated as follows:

It can be stated that a well performed operation followed by intensive local and general sulfonamide therapy and concluded by a closed plaster-of-Paris cast is, without any doubt, the best existing method for the treatment of compound war fractures including those of the femur. It is true for fresh wounds as well as for later cases. Even in the presence of a well developed infection, the same three principles remain the method of choice.

FRESH WOUNDS AND FRACTURES

There may arise two main objections to the principles stated for the treatment of fresh wounds and fractures. First, because of the great number of wounded to be dealt with during big battles, it is not possible to perform an extended careful wound excision upon every patient with a fracture of the femur because such a procedure requires too much time. Second, after imperfectly performed operations it is risky to apply a plaster-of-

Paris cast for fear of gas gangrene, so it is preferable to wait for some days until this danger is over and meanwhile keep the patient in a transport splint.

To answer both objections, it must be emphasized that simple incisions and tamponade with gauze, containing any kind of antiseptics or vaseline, cannot replace the necessary excision of all damaged and contused tissues, and the removal of foreign bodies. Simple incisions are not a surgical aid but are only a primitive temporary measure. Patients thus treated should be regarded as having undergone no surgical treatment at all. This conclusion is all the more just because such wounded remain or are evacuated in transport splints, that is, without satisfactory immobilization. Unfinished operations, poor immobilization, and inevitable subsequent dressings—all these may lead to conditions suitable for the development of infections, particularly of gas gangrene. An absurd situation arises, one is fearful of gas gangrene, and therefore avoids putting on a closed cast at once, and thus creates conditions favorable for the development of infection.

It is necessary that all wounded with fractures of the femur be transported as early as possible to special field hospitals where qualified and final aid can be offered to a great number of wounded by means of the "conveyor" method.

From the Surgical Department of the Institut Sklyfosowsky and the Surgical Clinic of the Central Post Graduate Medical School Moscow U.S.S.R.

The operative principles are as follows (1) wide excision of all injured and contused tissues regardless of the presence and degree of infection (2) no drains of any kind are used (3) continuous free drainage of the wound by means of a large counter-opening (4) suture of the edges of the skin with catgut to the deep fascia, thus turning the wound inside out by the elastic traction of the skin (5) during all the stages of the operation rich abundant washing of all parts of the wound with a soap solution (6) after the excision and washing of all wound surfaces and bone ends, the application to these areas of a mixture of sulfanilamide and sulfathiazole in the proportion of three to one finally the application of a closed non-padded plaster-of Paris cast

In order to perform these steps as quickly as possible and with convenience it is necessary to have an orthopedic table or some portable apparatus to obtain extension by means of screws. The table proposed for use (Figs. 1-3 4) allows not only great extension and reposition of bone and an easy way for applying the plaster cast in case of any necessary flexion and abduction but, what is most important the operation itself is more easily performed by taking advantage of the lateral tilting of the table. This secures the best access to the lateral and even posterior surfaces of the thigh and makes the task easy whatever the level of the wound and fracture (Figs. 5-18)

The typical lateral approach irrespective of the direction of the bullet or splinter and the

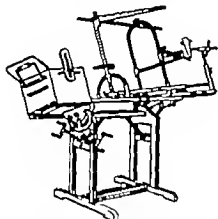


Fig. 1

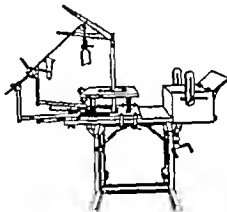


Fig. 2

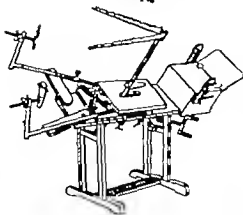


Fig. 3

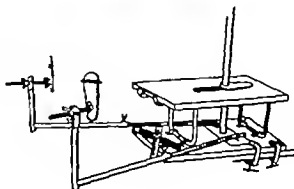


Fig. 4

Figs. 1, 2, and 3 are different views of the table used in our fracture work

obligatory suturing of the skin edges to the deep fascia to insure continuous gaping of the entire wound simplify and standardize the operation. A portable x ray apparatus is very desirable but one may operate and secure bone reposition even without films. However it is absolutely necessary to have a sufficient number of orthopedic tables or some kind of apparatus to obtain extension. Then one skilled surgeon with a sufficient number of attendants will be able to treat successfully a large stream of wounded.

The conveyor method used by a "thigh brigade" working simultaneously on three tables (Fig. 19-20-21) may be described as follows. At the first table after spinal anesthesia three trained medical orderlies apply extension and carefully wash the wounded. This

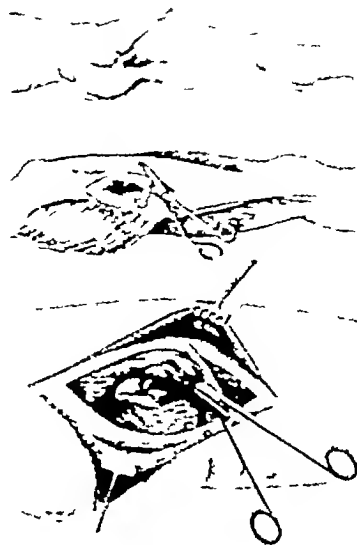


Fig. 5

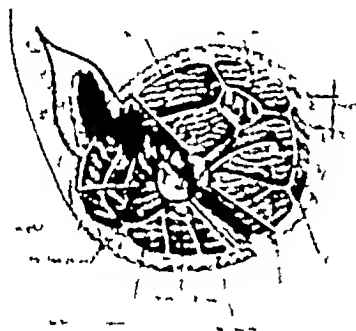


Fig. 6

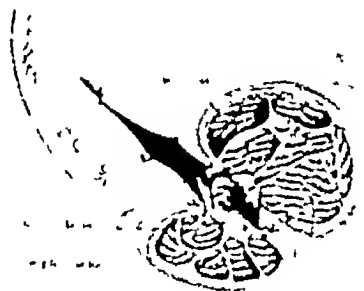


Fig. 7

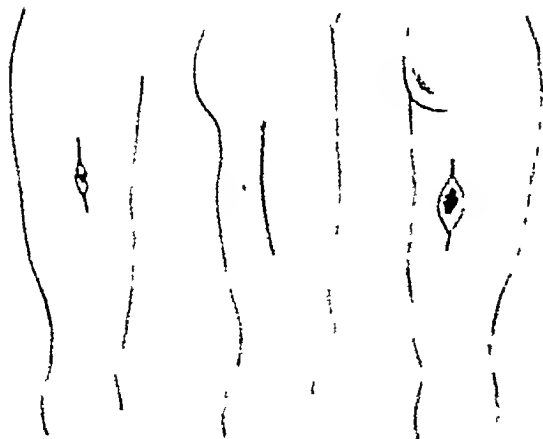


Fig. 8

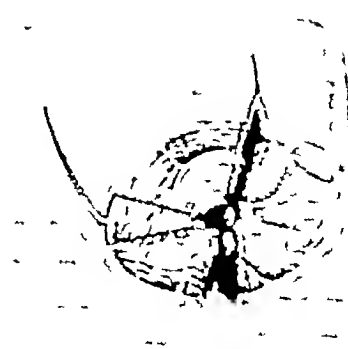


Fig. 9

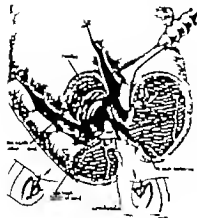


Fig. 2

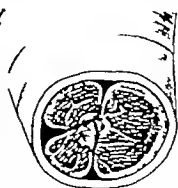


Fig. 1

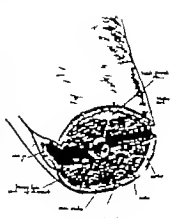


Fig. 3



Fig. 5

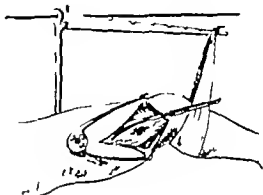


Fig. 4

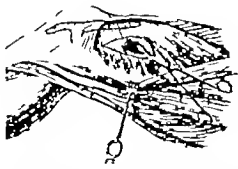


Fig. 5

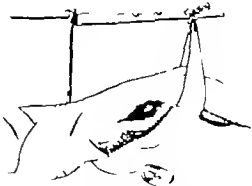


Fig. 6

Figs. 2, 3, and 4. Method of excision and suture of the skin edges in fracture of the middle third of the femur.
Figs. 5 and 6. Method of excision and suture of the skin edges in fracture of the lower third of the femur.

Figs. 5 and 6. Method of excision and suture of the skin edges in fracture of the lower third of the femur.

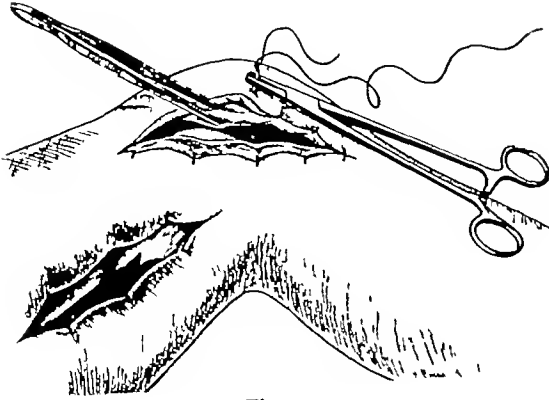


Fig 17

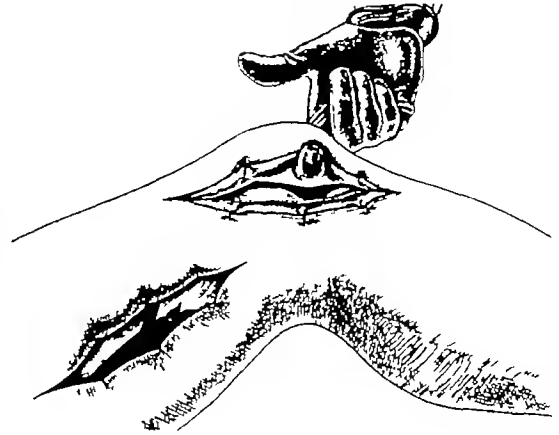


Fig 18

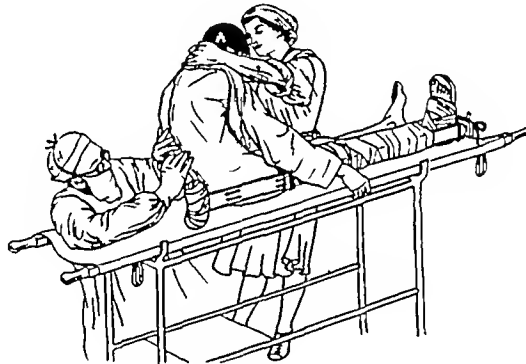


Fig 19

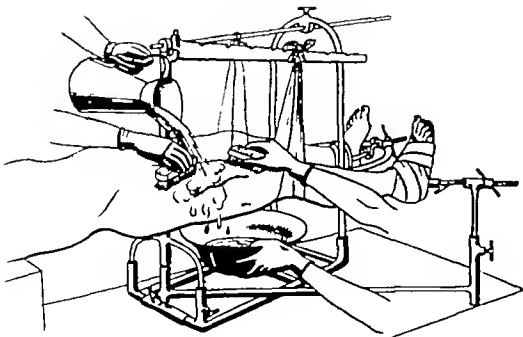


Fig 20

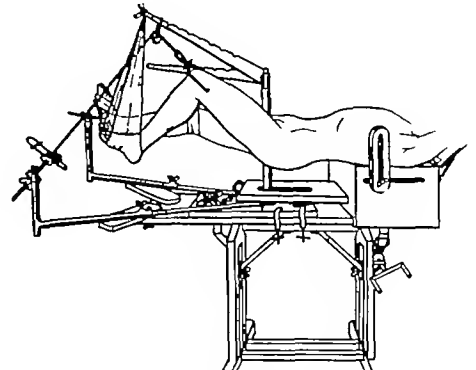


Fig 21

Figs 17 and 18 Excision of the wound with suture of both skin edges and arthrostomy for injury of the knee

Figs 19, 20, and 21 Steps in the conveyor method used by a "thigh brigade"

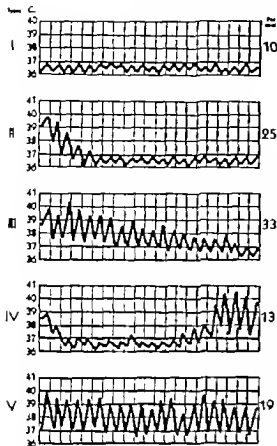


Fig. 22. Temperature curves in various clinical types of cases.

requires half an hour. At the second table the surgeon, with an assistant or an able nurse and second nurse passing the instruments, performs the operation. This step also requires half an hour. At the third table two able nurses put on the plaster cast with one who moistens the bandages and rolls out the padding. Another half hour including the cutting

TABLE L.—TIME ELAPSED BETWEEN RECEIPT OF WOUND AND OPERATION

Time in days after wound	Per cent
The first 3	6
From 3 to 5	24
From 5 to 7	95
From 7 to 10	0
More than 10 days	5.4

The condition on arrival was satisfactory 31 per cent, mildly grave 31 per cent, and severe 38 per cent.

TABLE II.—CHANGE OF THE PLASTER-OF-PARIS CAST

	Per cent
I. Absolute indications	8
Hemorrhage	4
Gas gangrene	
3. Gangrene	
4. Acute cellulitis	3
5. Sepsis	5
II. Direct indications	49
Contaminated fever	7.4
Secondary rise of temperature	3.9
3. Dislocation of fragments	4.7
4. Pains arising and softening the plaster	4
III. At the proper time	7
IV. Complete recovery in the first cast	35

TABLE III.—MORTALITY IN 500 CASES OF FRACTURES OF THE THIGH TREATED BY THE CLOSED PLASTER-OF-PARIS METHOD

	Per cent
Total mortality	5.4
On the first 3 days	
From 3 to 30 days	4
After 30 days	3

Cause of Death

Secondary hemorrhage	6
Gas gangrene	
General intoxication	1
Sepsis	
Tetanus	1
Accidental	1

of these per cent were from other hospitals in desperate state

of the edges and inscriptions on the cast is required.

So every patient requires an hour and a half of time, but every half hour one properly operated upon and definitely immobilized patient both for transport and future treatment leaves such a conveyor system. In this way one surgeon with 8 aids during a 16 hour work day can pass through 25 to 30 severely wounded with fractures of the thigh.

During two days such a brigade can fully attend to all fractures of the thigh, knee and hip joint in a thousand wounded men. If the wounded number not one but two thousand it is necessary to have two such brigades. These wounded not only receive complete surgical aid but later they will require only food and the most simple nursing care. More than 90 per cent of the patients so treated will be able to withstand evacuation into the deep rear quickly and in excellent condition and half of them will recover from their wounds with

complete consolidation of their fractures, in the first plaster cast

INFECTED WOUNDS AND FRACTURES

Surgeons during the first World War were afraid of active interference in infected wounds, particularly those associated with fractures but we have adopted a very definite and active practice in the opposite direction. We operate upon, excise, wash, and cover with plaster cast infected wounds and fractures in a more definite way, the more evident and acute is the infection.

Table I gives some data concerning more than 500 cases of war fractures of the femur that passed through my hands during the German offensive on Moscow in the autumn of 1941 and during two great battles around Rjev in 1942. More than 80 per cent of the patients came 3 to 15 days after they were wounded, and 15 per cent even later. Among such severe and infected material amputations were performed in 12 per cent. 66 per cent im-

mediately after their arrival because of lesions of large vessels, gas gangrene, and too extensive injuries with severe infection, and 54 per cent secondary amputations during the treatment with plaster-of-Paris cast, mainly because of a generalized septic condition. The types of temperature curves in the various clinical types of cases are shown in Figure 22. Table II shows the causes and indications which have brought about the necessity of changing the plaster cast immediately or before the required time. Table III gives the data as to mortality occurring during treatment.

As is seen, during 1941 and half of 1942 there was a mortality of 59 per cent. We count these results as good, the more so because at that time the general mortality in cases of war fractures of the femur in the Moscow hospitals reached 17 per cent. However, during the winter, 1942-1943, the mortality in these groups of cases in all the Moscow military hospitals decreased by 3 per cent.

PIROGOFF, quite independently of Matisen, began the treatment of fractures by using a plaster cast a year and a half before the Crimean war, i.e., at the very beginning of the year 1853. He was the first surgeon in the world who used this method in military surgery and on a very large scale during the siege of Sevastopol.

Pirogoff's *The Principles of the General War Surgery*, was published in Russian and German in 1865. This is a classical work on field surgery without an equal in any country in the 19th century. Pirogoff wrote about the advantages and merits of plaster cast in war time in two other books dealing with surgery during the French-Prussian War



Nicolaus Pirogoff
1810-1881

of 1870 and the Balkan War of 1877. In a special monograph on the subject of his *Alebastrer* plaster cast Pirogoff gave in full details the technique of the application of plaster casts upon the extremities particularly under wartime conditions.

"Although these fractures were always connected with considerable oedemas, etc. I treated them as well as in peace time immediately applying the plaster cast and I do not recall a single case which made me regret that I had proceeded thus, on the con-

trary, I remember several patients when I applied the closed plaster cast in spite of the perforation of the skin and wound healed without suppuration.

Der Gypskleebeverband

von

einfachen und complicirten Knochenbrüchen

und

in welcher die Anwendung beim Transport Transportmittel und in
dem Krankenhaus

von

NIKOLAUS PIROGOFF

Dr. med. u. Dr. phil. aus Petersburg, Professor an der Kaiserlichen Universität
in Petersburg, Mitglied der Kaiserlichen Akademie der Wissenschaften, Mitglied
des Kaiserlichen Senats, Mitglied der Kaiserlichen Gesellschaft der Ärzte,
Mitglied der Kaiserlichen Gesellschaft der Naturforscher, Mitglied der
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der Naturforscher, Mitglied der Kaiserlichen Gesellschaft der Ärzte,

KNIELEBEN MITTE

in der Kaiserlichen Universität in St. Petersburg

LEIPZIG

VERLAGER DR. WILHELM FRIEDRICH FRIEDRICH & WITTE

1881

Fig. 3. Title page for Der Gypskleebeverband by Pirogoff.

The conservative treatment is out of question for me without a complete immobilization of the fractured ends and that is why I consider the secondary malignant oedema in its acute stage to be the only counter-indication for the application of the closed cast. In cases of the primary traumatic swelling depending upon the blood extravasants, I consider the plaster cast to be the best preservative means against its further progress.

"It is not of extreme difficulty to make a plaster cast. I make it by two different means. I'll mention now about the time when my plaster cast must be applied. It must be applied at the First Aid Station for transportation or in hospital for the treatment. In the first case it is applied soon after the injury before the formation of swelling and suppuration and therefore it may be made even without windows if the patient is not going to be transported too far but in this case it is necessary to watch it during the transportation and take it off immediately when arriving at the hospital. The main thing is to keep the limb operated upon in the plaster of Paris cast.



Fig. 2. Result of immediate suture of flexor profundus of middle finger following division of both flexor tendons just proximal to web.

leaves all the flexor tendons bare and uncovered in the carpal tunnel and lower forearm the fingers can be flexed and extended with complete freedom if primary healing follows operative removal of the parietal layer of the tendon sheaths. It is hopeless, however to expect free movement if both tendon surface and tendon sheath are injured. To unite scarred ends of a tendon within a finger to attempt lengthening operations within a digit or to free a sutured tendon which has become adherent to the surrounding tissues with the hope that early movement will prevent reformation of the scar tissue which has been

divided are futile procedures, simply because they ignore the primary fact that at least one half of the normal gliding mechanism which nature has provided must be present if free movement is to result.

Only if one can repair a tendon injury immediately after its division can one be certain of having sufficient normal tendon to permit end-to-end suture (Figs. 1-2). Occasionally if no attempt at operative repair has been made and if the wound of injury has healed by primary union it may be possible to draw the separated ends of the tendon together without excessive tension and carry out end-to-end suture (Fig. 3). We have seen only a few cases in which this could be accomplished after a primary effort at repair had proved unsuccessful, because of the fibrosis and destruction of tendon tissue almost invariably present above and below the site of division. The advice sometimes given the surgeon to anchor a divided tendon to the surrounding tissues so as to prevent retraction and facilitate subsequent repair is ill conceived to say the least. Such a procedure simply leads to dense scar formation which makes subsequent operation unusually difficult and jeopardizes the final result. A healthy little traumatized tendon which has retracted into the palm can sometimes be brought distalward through an intact sheath and sutured to the distal end of the tendon but if the tendon is fixed by sutures to the surrounding tissues it is inevitably torn



Fig. 3. Result of immediate suture of flexor profundus following division of both flexor tendons proximal to proximal interphalangeal joint. (Case of Dr. Michael M. Mason.)

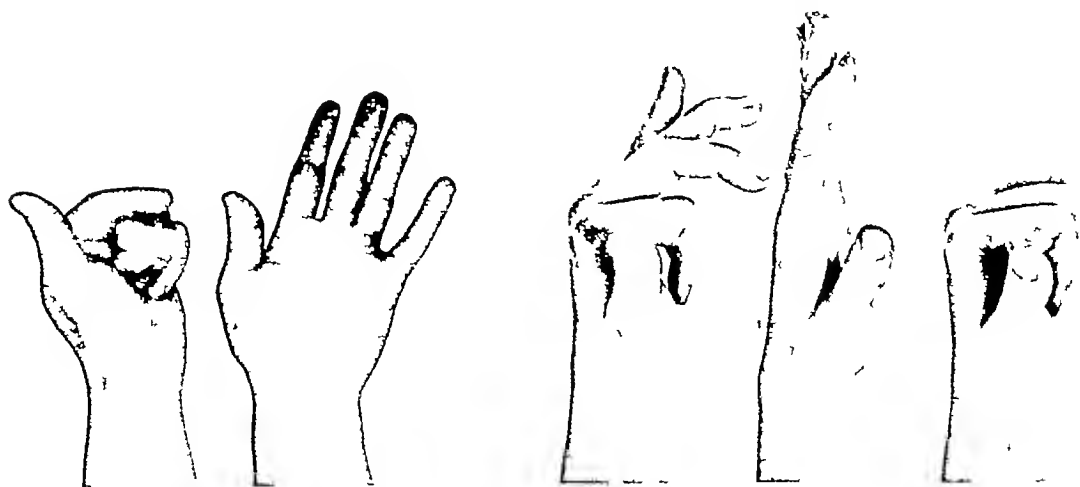


Fig 3, a

Fig 3 a, Result of suture 6 months after injury of flexor profundus of index finger divided at level of proximal interphalangeal joint Left, before operation, right, result 6 months after operation b, Diagram showing condition before operation and restoration of tendon sheath with aid of graft from foot

away by the constant tension to which it is subjected The extent of the resulting fibrosis of both tendon and surrounding tissues can only be appreciated when one later attempts repair

If the available tendon is irreparably damaged how can one provide normal uninjured tendon? Two methods are available one, to divide the sublimis tendon through a transverse incision just above the wrist, draw it out through the palmar incision and use it to bridge the gap between the ends of the profundus, the other, to use one or two of the flat, long extensor tendons from the dorsum of the foot, since the long extensor tendons of the lateral four toes can be removed without loss of extensor function of the toes The first method has the advantage of avoiding an additional incision over another extremity, and of providing a tendon graft which is of the same caliber and strength as the tendon ends which the graft is to unite If the affected digit is the thumb with its single long flexor tendon, or if sublimis and profundus are so firmly fused in the palm that they cannot easily be separated one has no recourse except to use one or two of the long extensor tendons from the dorsum of the foot

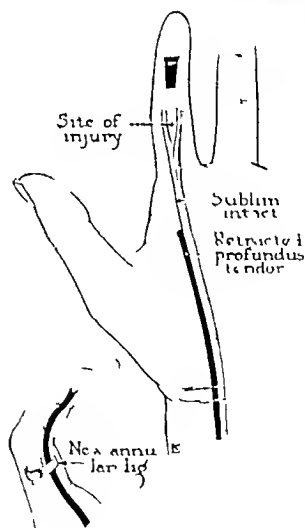


Fig 3, b

A retentive mechanism to hold the tendon in place over the volar surface of the flexed finger and prevent it from being drawn taut like a bowstring under the palmar skin when tension is put upon it is also an essential part of the normally functioning mechanism of the finger The synovial sheath, with its visceral layer covering the tendon and its parietal layer lining the fibrous sheath, permits gliding movement The outer fibrous sheath holds the tendon in place over the concavity of the flexed finger as the finger is drawn into flexion If the fibrous sheath is destroyed or if its



Fig. 4. Incisions for exposure and repair of divided tendons if made along flexor creases best with minimum of scar and disabling contracture.

edges cannot be approximated without crowding the tendon unduly within a narrow space it must be replaced. If the loss of fibrous sheath is not too great it may be possible to divide it partially at one side, draw it across the tendon as a flap and suture its free edge to the corresponding fibrous tissue on the opposite side. If this cannot be done one must pass a slip of normal tendon around the finger, suture the ends and so form a new annular ligament (Fig. 5).

It is hardly necessary to emphasize the need of normal mobility at interphalangeal and metacarpophalangeal joints if tendon repair is to be followed by satisfactory function. Sutured tendons are handicapped at best. If the patient cannot bend the injured finger easily with his uninjured hand and if it springs back into extension like a strip of spring steel when tension is released it is obvious that no sutured tendon or tendon graft could be expected to draw the finger into flexion. Often the first step in treatment of the patient with injured flexor tendons is physical therapy directed toward securing increased mobility and restoration of passive flexion at interphalangeal and metacarpophalangeal joints.

With the conditions necessary for success in mind we wish to discuss briefly the details of technique that have impressed us as of particular importance.

1. *Incisions.* Bunnell more consistently than anyone else has stressed the importance of avoiding scar contractures by making incisions along flexor creases and parallel with lines of skin cleavage and not across them. Figure 4 indicates the incisions ordinarily used in the repair of injuries of the flexor tendons within the fingers. Through these incisions the injured tendons are exposed, freed and sutured.

Needless to say, in choosing the exact site and in determining the length of the incision, one is guided by the position of the original wound and the position in which the hand was held at the time of injury. If the tendons in finger or palm are divided when the fingers are completely extended the distal segments which have no contractile power lie close to the site of injury; the proximal segments are drawn far proximally by the contraction of the affected muscles. If, on the other hand, the fingers are tightly flexed at the time of injury there will be relatively little further retraction of the proximal segments but the distal segments are retracted distally to a surprisingly great distance when the fingers are extended. It is not uncommon in such a case to find the distal segment of the divided profundus at the level of the proximal interphalangeal joint even though the division has taken place in the middle of the palm.

2. *Preservation of the fibrous tendon sheath.* The fibrous tendon sheath is opened by an incision close to its attachment to the bone, never by a median incision. Even if the empty sheath is completely collapsed it may be possible to open it, save the roof and use it eventually as a flap to lay over the repaired tendon and hold it in place. Under such circumstances care must be used not to injure its synovial lining.

If the sheath is collapsed and its walls have become adherent to one another one must remove the roof, preserve the floor and construct a new retaining mechanism.

3. *Immobilization of divided tendons.* If a tendon is frozen within its sheath it must be freed

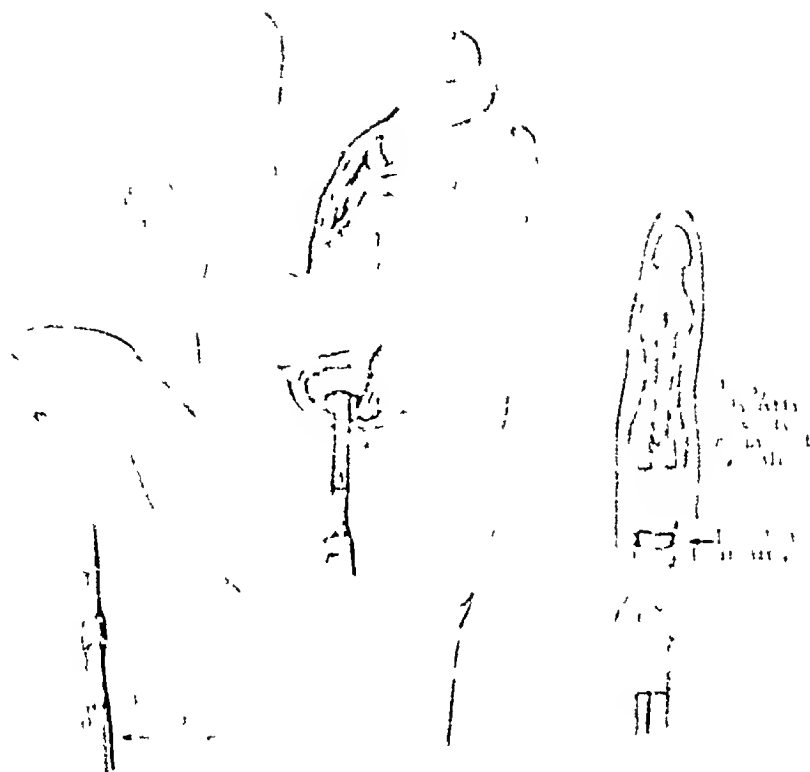


FIG. 1. Proximal technique of approach and exposure of flexor tendons when distal have curved at level of web. A curved double edged scalpel is helpful in separating the tendons from the surrounding sheath over the proximal phalanx.

with particular care to leave the sheath as nearly uninjured as possible. The greatest difficulty commonly encountered is over the proximal phalanx and if the original injury has been at or near the level of the web in freeing the distal segment of the profundus from the slips of insertion of the sublimis so that the distal phalanx is easily flexed when tension is put upon the freed profundus. To free the tendons fixed within the sheath overlying the proximal phalanx we have found a double edged curved blade (Fig. 5) useful. By inserting the curved knife beneath the tendons and between tendons and overlying sheath, first by working distalward from the palmar incision and then proximalward from the incision at the side of the finger the tendons are gradually freed.

When the tendons are completely freed within the finger the proximal segment or segments of the tendons are freed within the

palm. As they are drawn distalward one invariably finds they are held more or less firmly to the surrounding tissues. Fibrous adhesions are divided cleanly as far proximalward as possible. Sometimes in drawing the proximal segments of the tendons distalward a lumbrical muscle comes into view, giving the appearance of an umbrella which has been turned inside out by a gust of wind. The profundus retracting proximalward immediately after its division draws the lumbrical muscle with it. The muscle, often torn by this sudden tension becomes adherent and more or less firmly fixed to the surrounding tissues. As the surgeon draws the retracted tendon distalward into the field of operation the level of origin of the muscle comes into view while the more distal portion of the muscle still remains fixed to the surrounding tissues. It is this condition that causes the inverted umbrella appearance. If the lum-



Fig. 6, a.

Fig. 6. a, Substitution of graft of flexor sublimis to fill defect between widely separated ends of flexor profundus of middle finger. Left, before operation; right, result months later. b, Diagram showing technique of operation.

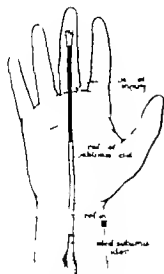


Fig. 6, b

lunical muscle has been partly or completely divided at the time of the original injury the eversion as the retracted tendon is again drawn distalward becomes complete. It may be necessary to excise a part of the lumbrical muscle so that its attachments to the surrounding tissues do not interfere with subsequent freedom of movement. In some cases a part of it can be used to cover the line of suture in the palm and form a barrier of soft tissue between sutured tendon and overlying skin.

4. *Tendon grafts to bridge defects* (Figs 6-9) With the tendons well exposed one can determine the best method of restoring continuity

Rarely in secondary injuries is it possible to bring widely retracted segments together without excessive tension. If clean cut tendon ends cannot be approximated without abnormal tension one must use a graft to fill the defect. If one is repairing tendons of index, middle or ring fingers, unless the tendons are so completely fused in the palm that the sublimis and profundus cannot be easily separated from one another the simplest procedure is to expose the tendons just above the wrist, divide the sublimis tendon of the affected finger and draw it out through the palmar wound. The smoother normal proximal portion is used as the graft. If the thumb or little finger is involved or if the two tendons of any of the other digits are fused into a single tendon one must secure the graft from the foot. In the thumb obviously there is no sublimis which can be utilized. In the little finger the sublimis is so small and slender that one would prefer not to use it as a graft between the ends of the considerably larger and stronger profundus. Whatever the tendon chosen as a graft one tries to leave a covering of areolar tissue attached to its surface and not "skin it out" of its bed as it is removed. It is advantageous also to insert the stay suture in the tendon to be used as the graft before it is detached. To insert a suture with exactness in a loose slippery tendon held in moist gauze is a difficult feat.

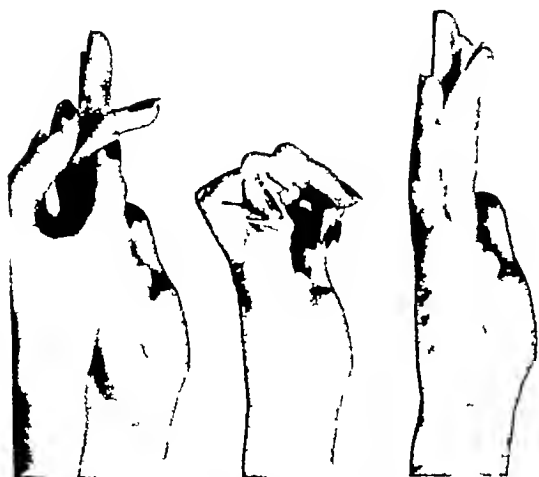


Fig 7, a

Fig 7 a, Result of substitution of graft of flexor sublimis to fill defect between widely separated ends of flexor profundus of ring finger b, Diagram showing technique of operation

Fig 8 a, Result of substitution of graft of flexor sublimis to fill defect between widely separated ends of flexor profundus of ring finger b, Diagram showing technique of operation

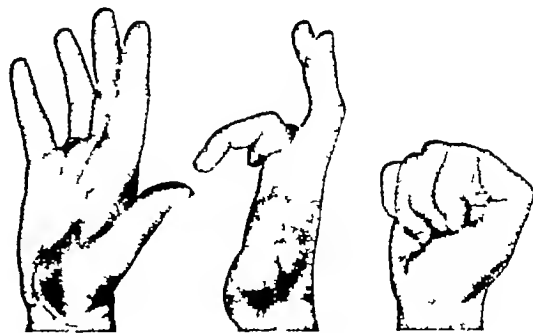
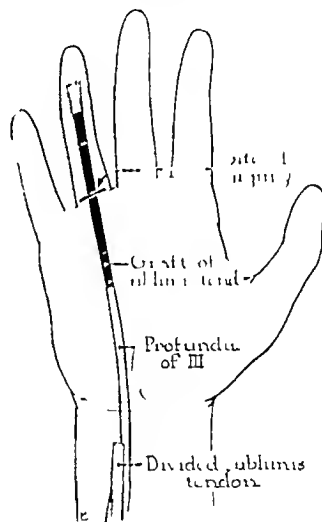


Fig 8, a



Figs 7, b and 8, b

5 *Tendon suture* Ragged tendon ends are cut away so that one can bring healthy clean cut ends into apposition. If a graft is used the graft is carefully drawn through the sheath overlying the proximal phalanx, and end-to-end suture of graft to the distal segment of the profundus carried out (Fig 10). Whether for uniting tendon ends or uniting graft to tendon we have in recent years constantly used the type of suture which Mason and Allen in their extensive experimental work found to give the most satisfactory results from the standpoint of firm healing, tensile strength and freedom from irritation and foreign body reaction. They have shown that the ends of the tendon should be as free as possible from any foreign material if rapid re-formation of fibrous tissue and tendon tissue is to take place at the site of approximation. Knots between tendon ends and sutures woven back and forth close to the cut surface of the tendon act as foreign bodies, set up inflammatory reaction and cause deviation of regenerating fibers from the direct vertical line in which they should lie. For the stay suture we have used No. 6 Champion silk,

occasionally in very stout tendons, No. 8, for edge-to-edge approximation 8 nought silk swaged on the needle (atraumatic suture).

Because of the excellent results that have been obtained with silk sutures inserted as described we have been reluctant to use steel wire, which experimentally is difficult to tie with exact tension because of its elasticity, and difficult to use without damaging rubber gloves. We have been quite unwilling to thread steel sutures through tendon ends or tendon grafts with the idea of removing them at a later date, a procedure recommended by Bunnell. If tendons can be sutured end-to-end we would be reluctant to expose any more of the tendon than necessary for insertion of the required sutures. If a graft is used it is difficult to see how a double strand of steel

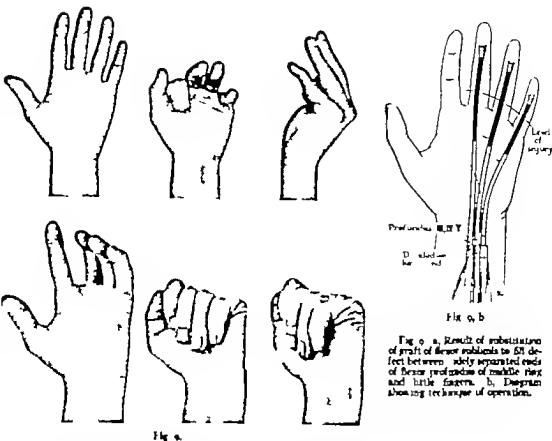


Fig. 9. a, Result of substitution of graft of flexor profundus to 5th defect between widely separated ends of flexor profundus of middle ring and little fingers. b, Diagram showing technique of operation.

wire could be passed through it longitudinally without damaging the graft and its covering. To remove it without causing injury might be difficult. Occasionally two flat tendons from the foot are used: one laid over the other to replace a single stout flexor tendon. To thread sutures through two grafts so placed would add still further difficulties. It is our belief that we shall make progress by simplifying our surgical procedures as much as possible rather than by making them more complicated.

6. *Reformation of the fibrous sheath.* If the line of suture lies over the middle phalanx the sheath is reconstructed as well as possible but care is taken not to lay sheath tissue too close to the line of suture. Tendons heal a deal on by callus formation and with moderate temporary thickening at the line of union.

There must be sufficient space for the thicker calloused portion of the tendon to move back and forth without any constricting obstruction. Furthermore and in this fact we believe lies the fallacy of surrounding a sutured tendon with any type of artificial membrane: the nutrition of the tendon within the finger must come in part from the capillaries of the subcutaneous tissue which overlies it. The central artery of the tendon itself is so minute it cannot be seen with the naked eye. The blood supply of the distal portion of the tendon comes through a very small and slender mesentery. Blocking off the ingrowth of blood vessels at the line of suture jeopardizes the sound healing of the sutured tendon ends which is the first essential to restoration of function.

If the sheath tissue remaining is insufficient to hold the tendon in place over the palmar

THE RE-ESTABLISHMENT OF ESOPHAGOGASTRIC CONTINUITY FOLLOWING RESECTION OF ESOPHAGUS FOR CARCINOMA OF MIDDLE THIRD

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IT is fair to state that, following a fairly extensive trial by numerous surgeons throughout the country during the past 7 or 8 years, the operation of transthoracic resection and esophagogastric anastomosis for squamous cell carcinoma of the distal esophagus and adenocarcinoma of the cardiac end of the stomach, has been generally accepted as a more or less standardized procedure and that it has withstood the scrutiny of careful follow-up studies. As has been emphasized in previous papers on the subject, this has been made possible first, by a more thorough knowledge of the physiological changes that occur during open thoracic operations and the employment of methods to counteract any harmful effects of these changes, second, by the great advances in recent years in the science and art of anesthesia, third, by refinement in the technique of suture methods applied to the esophagus, and, finally, by the application to the esophagus of the principles of good cancer surgery already known and employed in other parts of the body, namely, free exposure, wide resection of the cancer-bearing focus and removal of all the associated lymph nodes. With proper selection of cases and increasing experience in the technical maneuvers of the operation, it may be confidently predicted that the operative mortality will gradually fall to a reasonable level and that many more patients will be restored to a normal useful life.

The story of cancer of the middle third of the organ has, to the present writing, not presented as encouraging an outlook. The operation always employed was that described by Torek in 1913 or the modification of it that I reported a few years ago. Essentially this

involved resection of the entire thoracic esophagus, the formation of an esophagostomy stoma on the upper anterior chest wall and the connection of this stoma and the gastrotomy or lower esophagostomy by a rubber tube. In order to obviate the use of an artificial rubber esophagus, attempts have been made to reconstruct a skin-lined esophagus on the anterior chest wall, the so called antethoracic esophagoplasty. The latter requires numerous time-consuming stages which are always attended by the risk of sloughing of skin flaps, infection, fistula formation, etc. I was never satisfied with this operation for cancer of the middle third of the organ because it was necessarily makeshift in character and left the patient with a rubber mechanism which was both distasteful and subject to mechanical difficulties.

Other surgeons, too, have frequently voiced their dissatisfaction with the Torek operation and some of them have attempted to devise procedures to take its place. The pioneer in this respect was Lilienthal who devised a very ingenious operation consisting of a posterior extrapleural approach and the utilization of a skin flap from the back to bridge the defect in the organ following the removal of the cancer-bearing portion. In the light of our present knowledge of the pathological aspects of the disease, the objections to the Lilienthal operation are that the exposure was not free enough and that the operation was not radical enough. Other operations have been suggested, and some have been carried out in the experimental laboratory and a few on the human. These vary from the utilization of tubes made from the stomach wall to loops of small bowel or even segments of colon. It is immediately apparent, after careful scrutiny, that the utilization of a loop of small intestine to form a new esophagus intrathoracically is fraught with



Fig. 2. Roentgenogram of esophagus showing an inoperable stenosing lesion at the level of the fifth thoracic vertebra.

great danger from the standpoint of blood supply of the transplanted loop. I believe that such an operation in the human is neither technically feasible nor desirable.

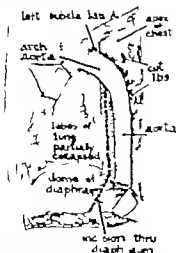


Fig. 3. Diagrammatic view of contents of left thoracic cavity, indicating incision in mediastinal pleura and left level of diaphragm.



Fig. 4. Diagram showing skin incision and the site of section of the sixth, seventh, eighth and ninth ribs, thus affording adequate exposure.

Recently Kay reported a two stage operation which makes use of a tube fashioned from the greater curvature of the stomach after the method of Jianu. At the first operation a long tube of stomach extending from pylorus to cardia is fashioned along the greater curvature the pedicle being located near the cardia. The tube is pushed into the left pleural cavity so as to lie on the upper surface of the diaphragm. At the second stage 10 to 14 days later the left chest is opened and if an operable lesion is demonstrated the esophagus is excised and the previously prepared gastric tube is anastomosed to the stump of the esophagus. The main objection to this plan is quite obvious when applied to the human before it is determined whether or not the esophageal carcinoma is operable the patient is subjected to the risks of an operation of considerable magnitude—the first stage—aside from the fact there is a possibility the gastric tube may slough. If an inoperable lesion is demonstrated at the second stage then the first procedure has been for naught. If one were able to predict an operable neoplasm beforehand then Kay's procedure would have great merit and might very well be the answer to the treatment of cancer of the middle third of the esophagus.

For the past 2 years I have had a different plan in mind and by anatomical studies, have been attempting to determine the feasibility of its use in the human. After it seemed that there would be a reasonable chance of success the operation was performed upon a patient for the first time in May of 1943 and the patient came through with minimal disturbance.

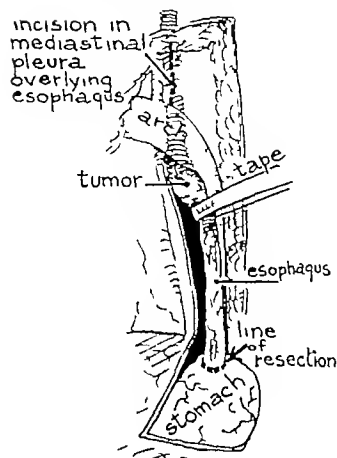


Fig 4

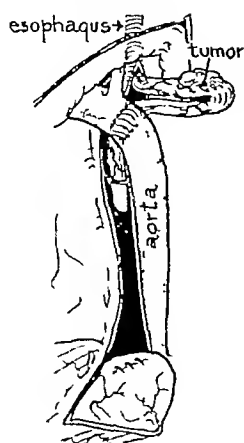


Fig 5



Fig 6

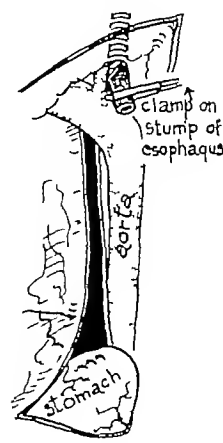


Fig 7

Fig 4 The esophagus has been freed from the mediastinum from arch of aorta downward. The supra aortic mediastinal pleura has been incised. The tumor has been freed from its attachment to the aortic arch.

Fig 5 The supra aortic portion of the esophagus has been mobilized and the entire organ is being drawn upward from behind the aortic arch. The cardiac end of the stomach has been doubly inverted with silk sutures.

Fig 6 The pulling through procedure has been completely accomplished and the mobilized organ rests over the aortic arch.

Fig 7 The esophagus has been divided well above the tumor and the stump is guarded by a small noncrushing clamp covered with soft rubber. This is necessary in order to minimize contamination from the highly infectious esophageal contents.

TECHNIQUE

The operation, applicable for cancers of the esophagus situated in the middle third, i.e., behind or just below the arch of the aorta, consists of a left transthoracic resection of the entire esophagus up to the upper border of the aortic arch and down to and including the cardia, mobilization of the upper two-thirds of the stomach by a precise ligation of its upper vessels, the transplantation of the stomach toward the apex of the chest over the arch of the aorta and the performance of an anastomosis between the esophageal stump and the stomach cephalad of the aortic arch near the apex of the chest. In spite of the fact that our patient presented a long thoracic cavity, it was surprising to see with what ease the stomach could be brought to the apex of the chest without tension and without interference of its blood supply.

This experience has demonstrated that the main problem is not that of bringing the stomach to the thoracic apex but is one concerned chiefly with the blood supply of the esophageal stump and of the stomach. Careful anatomical studies have shown that the main, if not the only, arterial supply of the supra-aortic

portion of the esophagus is through small branches of the inferior thyroid artery. Apparently, the nutritional integrity of this portion of the organ is adequately cared for by these vessels if the esophagus is not separated

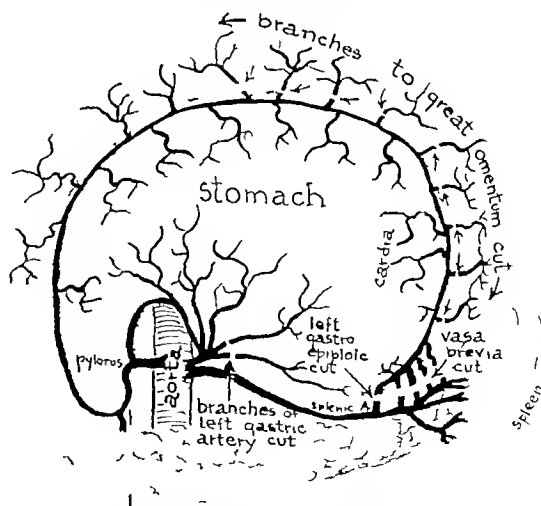


Fig 8 Diagrammatic sketch of the blood supply of the stomach (turned upward), indicating the precise ligation of the vessels supplying the upper half of the organ. In the case reported, the upper two branches of the left gastric artery were divided.

as showing infiltrating anaplastic carcinoma in the submucosa. Bronchoscopy was performed and was negative.

The barium meal examination showed "an irregular stenosing lesion of the midesophagus at the level of the 8th dorsal vertebra. About it was a soft tissue mass. There was moderate dilatation of the esophagus above." X-ray examination of the chest showed no abnormality. The electrocardiogram was normal.

Preoperative preparation consisted of (1) high caloric liquid diet, (2) daily cleansing irrigations of the esophagus, (3) oral administration of sulfanilamide for 3 days prior to operation.

Operation was performed on May 8, 1943, 9 days after admission. Positive pressure cyclopropane anesthesia was used. An incision was made in the 7th interspace and continued upward close to the spine. Incision was deepened, the musculature was divided, and the chest cavity was entered through the 7th space. The 7th, 6th, and 5th ribs were divided close to the spine. In order to permit a more free exposure at the lower part of the chest, the 8th and 9th ribs were also divided to form a T-shaped incision of the thoracic cage. A rib spreader was inserted and the following pathology was demonstrated. There was a large lymph node lying on the anterior and mesial aspect of the aorta about 1 inch below the neoplasm which was located in the middle third of the organ, its upper border being situated about $\frac{1}{4}$ inch below the under surface of the aortic arch. The lymph node was freed from the adventitia of the aorta and left attached to the esophagus. The esophagus was now freed from the mediastinum, the tumor bearing portion being separated eventually from the adventitia of the aorta to which it was intimately connected. The tumor measured about 2 inches in length and was stony hard in consistency. It was freed from the mediastinum without perforation of the right pleura. A radial incision was made in the diaphragm from the hiatus outward. The phrenic artery was ligated. There was found another node at the esophagocardiac junction on the lesser curvature side. This measured $\frac{1}{2}$ inch in diameter. A third node of the same size was found on the superior border of the pancreas near its tail. A hand inserted into the abdomen was able to palpate the preaortic tissues and no further node enlargement was found. It was decided to attempt an anastomosis be-



Fig. 11. Roentgenogram taken 5 weeks after operation showing position and size of transplanted stomach and site of anastomosis.

tween the stomach and the esophagus above the arch of the aorta. The vessels along the greater curvature of the stomach were ligated and divided as far down as the middle of the greater curvature. The left gastric artery was not divided at its origin but its upper 2 branches along the lesser curvature were isolated and cut between ligatures. This was done in order to insure adequate blood supply of the upper stomach following its transplantation. The lymph node and the surrounding tissues were removed from the tail of the pancreas. The cardiac end of the stomach was cut across between clamps below the node described and the upper end of the stomach was closed over with two layers of silk. The stump of the esophagus was covered over with a rubber dam. It was now found that the stomach could be drawn into the chest as far as the apex, without tension. The esophagus was bluntly dissected free from the space between the arch of the aorta and the left main bronchus and drawn upward so as to lie completely above the arch. After the pleural cavity was

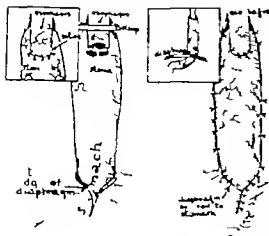


FIG. 2. Left, The stomach, now appearing greatly elongated, has been drawn upwards over the arch of the aorta and an end-to-side anastomosis is being effected between the stump of the esophagus and the anterior wall of the stomach. Inset shows completion of the two-layer anastomosis.

Fig. 2. Right, The esophagus has been telescoped into the stomach to eliminate tension on the suture line. The transplanted stomach is seen to the mediastinal pleura and to the cut edges of the diaphragm, which is then sewn up to the transplanted stomach. Inset shows completed procedure.

too extensively from its upper mediastinal attachments and if kinking of the organ is carefully avoided. There may be anatomical variants in these vessels, but apparently they are quite unusual and of course unpredictable.

The blood supply of the upper stomach is also an important item in the success of the operation. Inasmuch as it is not necessary to remove any more than the cardiac end of the organ, more of the stomach becomes available for transplantation than is the case with adenocarcinoma of the cardia in which case a wider resection must be done, thus requiring ligation of the main left gastric artery. In the case reported herewith it was demonstrated that it was necessary to ligate *only* the upper two branches of the left gastric artery as it fans out along the lesser curvature. I believe that if the main vessel were ligated the blood supply of the upper end might be seriously jeopardized. Along the greater curvature the vasa brevia vessels and the left gastroepiploic artery and branches down to the middle of the greater curvature may be safely divided in or-

der to secure adequate mobilization. It seems important to stress, therefore, that the problem in this operation is not that of bringing the stomach to the apex of the chest but one of blood supply of the two organs the surgeon wishes to join together. He must therefore exert every care to insure adequate nutrition of the two structures in order to prevent necrosis and a certain fatal issue.

There are many pertinent questions that arise with respect to the later effects of this operation upon the patient. Will there be any effect on the cardiovascular apparatus incident to the new position of the stomach? Will regurgitation of gastric contents occur and to what degree? Will distention of the stomach disturb pulmonary activity or respiratory physiology? Will digestive disturbances result from the new unusual position of the stomach? The answers to these and other problems that may arise will form the basis of a subsequent report. Suffice it to say that so far no untoward symptoms have developed. The operation is reported as a feasible solution to the problem of cancer of the middle third of the esophagus, one which eliminates artificial swallowing devices and restores the normal act of deglutition.

CASE REPORT

Hospital No. 5048 B A 35 year old Lithuanian elevator operator was admitted to the Mt. Sinai Hospital on April 30, 1943 complaining of dull pain in the anterior right chest region for 3 months and difficulty in swallowing for 3 weeks prior to admission. The dysphagia was progressive, solid foods were regurgitated and he was unable to swallow any liquids when admitted. The patient lost 3 pounds during the 3 month period.

Examination showed a well developed fairly well nourished male. Enlarged nodes were felt in the neck. The heart and lungs were negative. Blood pressure was 120/80. Abdominal and rectal examination was negative.

Laboratory studies disclosed hemoglobin, 95 per cent; white blood cells, 600 segmented forms; 76 per cent lymphocytes, 1 per cent monocytes, 7 per cent basophiles, 3 per cent eosinophiles, 3 per cent. The urine was negative. The blood Wassermann, negative. The blood urea nitrogen was 13 milligrams per cent; total protein 6.6 per cent; vital capacity 3,800 cubic centimeters.

Esophagography revealed circular tumors in the course of the esophagus, margins 35 centimeters from the upper incisor teeth. The biopsy specimen report:

GANGRENE COMPLICATING FRACTURES ABOUT THE KNEE

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VASCULAR complications following fractures about the knee are dependent upon certain anatomical relationships of the main vessels to the femur and to the tibia and fibula. The site of the fracture rather than the degree of displacement is the important factor.

In a review of the cases seen in civil life up to 1933 Dodd listed 20 cases of gangrene following fractures in the period 1850 to 1900. The series included all the extremities. Laceration of the vessels occurred in 7 cases and thrombosis of the main artery in the remaining 13 cases. In the period 1900 to 1914 there were 6 cases reported, and laceration of the main vessel occurred in an equal proportion compared to thrombosis. In the period 1918 to 1933 there were 11 cases reported. Thrombosis of the main artery occurred in all the cases but one which was diagnosed traumatic arterial spasm and recovered without an amputation.

Von Susani reported 4 cases in 1933. Three of his cases were fractures of the proximal tibia and 1 a fracture of the distal tibia. Two patients were treated by incision of a rapidly forming hematoma, and there resulted an infection with subsequent gangrene. No anatomical dissections were performed so one can only surmise that, because of the rapidly forming hematoma, he was dealing with a laceration of the vessels.

Titte (5) in 1935 reported 1 case in which a fracture of the mid-third of the femur resulted in a thrombosis of the popliteal artery with subsequent gangrene of the leg up to the knee. In 1938 Titte (7) reported another case of gangrene of the foot following a fracture of the distal third of the tibia and fibula. Dissection revealed a thrombosis of the vessels in the region of the fracture. Again in

1930 Titte (6) reported a case of gangrene resulting from a fracture of the distal tibia which dissection revealed as a thrombosis of the vessels.

Ottolenghi and Spinelli in 1939 reported 1 case of a fracture of the mid third of the tibia with subsequent gangrene which dissection proved to be a thrombosis of the arteries.

Stulthel in 1941 reported 2 cases of gangrene. One case was that of thrombosis following fracture of the tibia, and the other case that of thrombosis following fracture of the head of the fibula.

During the last 12 months there have been 4 cases of gangrene following fractures about the knee treated by the orthopedic staff at this hospital. The first case was that of a fracture of the proximal tibia with a fracture of the head of the fibula.

CASE 1. The patient I. I., a 39 year old colored female was injured when struck by an automobile. Examination on entrance revealed no gross deformity of the knee and there was no sign of vascular embarrassment. X-ray examination (Fig. 1) revealed a fracture of the proximal end of the tibia and a fracture of the head and neck of the fibula. A Steinmann pin was placed through the os calcis, reduction was performed and a long leg cast applied. The next day the toes were cold and anesthetic to pinprick. The cast was opened anteriorly but the anesthesia persisted, the toes became discolored, and dry gangrene became well developed so that 10 days later a definite line of demarcation could be seen just above the ankle. An amputation 6 inches below the knee was performed on the 20th hospital day.

Examination of the amputated leg revealed a gangrenous foot sharply demarcated by friable tissue at the level of the malleoli. The foot was dry, black, and wrinkled. Cut section below the demarcated area showed necrotic tissue. The vessels were traced and found to be occluded, about 2 inches above the area of demarcation, by thrombi.

The mechanism of the occlusion was thought to be that of thrombosis of the vessels at the level of the bifurcation of the

From the Milwaukee County General Hospital. Dr. King, director of surgery.



FIG. 1. Lateral and anteroposterior roentgenograms of the knee in Case 2 demonstrating fracture of the proximal tibia and fracture of the head and neck of the fibula.



FIG. 2. Anteroposterior and lateral roentgenograms of the lower half of the femur Case 3 revealing comminuted fracture of the distal third of the femur.



FIG. 3. Anteroposterior roentgenogram of the knee in Case 3 showing fracture of the lateral tibial plateau and fracture of the head of the fibula.

popliteal artery due to the injury to the intima with the thrombi becoming loose in the vessels and traveling distally as emboli.

CASE 4. Comminuted fracture of the lower third of the femur. The injury was sustained when the



FIG. 4. Anteroposterior and lateral roentgenograms of the knee in Case 4. There is fracture of the tibia and femoral articular surfaces with posterior and medial dislocation of the tibia.



Fig 5



Fig 6



Fig 8

Fig 5 An actual dissection of the popliteal fossa. The skin has been reflected and the fat excised thus exposing the popliteal artery and the muscular boundaries of the fossa.

Fig 6 An actual dissection of the popliteal fossa. The biceps femoris muscle and the semimembranosus muscle have been widely reflected and the fusion of the two heads

of origin of the gastrocnemius muscle opened, thus exposing the course of the popliteal artery in the popliteal fossa.

Fig 8 An actual dissection of the anterior tibial artery. The tibialis anterior muscle has been reflected, thus exposing the course of the anterior tibial artery through the hiatus between the neck of the fibula and the proximal tibia.

patient, J S, a 38 year old white male, was thrown from an automobile. He entered the hospital in a critical condition due to a severe head injury, and in traumatic shock. Examination revealed a fracture of the lower third of the femur with a small puncture wound on the medial side of the thigh. The area about the fracture site was diffusely distended with blood. The leg below the knee was pale and cold. The pulsation of the dorsalis pedis artery was absent, and the leg was anesthetic to painful stimuli. X-ray examination (Fig 2) revealed a comminuted fracture of the lower third of the femur. Reduction of the fracture was accomplished by the use of skeletal traction through the tibial tubercle and the reduction was maintained by a Boehler frame. He was given several transfusions, but his condition remained unimproved. The leg became mottled and gangrenous below the knee with multiple bleb formation. A midthigh amputation was performed on the 18th hospital day, but the patient did not respond to therapy and expired on the 20th hospital day.

Examination of the amputated leg revealed a black, gangrenous leg up to the level of the knee. The tissue from the knee to the point of amputation at the midthigh was necrotic and infected, and the muscles were diffusely infiltrated with blood. Dis-

section of the vessels revealed a complete laceration of the popliteal artery at the level of the fracture.

CASE 3. A so called "bumper-fracture." The patient, L J, a 49 year old white male, sustained the



Fig 7 Lateral and anteroposterior roentgenogram of the knee following the injection of an opaque media into the lumen of the popliteal artery.

branches of this segment in the arterioles, and even in the capillaries. This spasm could extend over to the collateral vessels and make itself manifest in the neighboring vessels even at a distance. Then too as pointed out by do Takats when a larger artery is suddenly obstructed the blood pressure below the point of obstruction must fall. This fall has been measured and, so long as the residual pressure is maintained by the collateral circulation no secondary thrombosis occurs. The collateral circulation is in turn dependent upon the cardiac output, on the site of the occlusion, and on the state of the collaterals. The only factor that one can control in therapy is the condition of the collateral circulation.

Gage and Ochaner (10) proved that sympathetic block definitely counteracts the pathologic physiology produced by the occlusion of the main artery in the extremity. By doing chemical sympathectomies they were able to produce dilatation of the main peripheral arteries vasodilatation of the collateral arteries increase the blood volume flow through the main and collateral arteries, and thus prevent ischemic gangrene.

We believe that an initial chemical lumbar sympathectomy with novocain should be performed as soon as the diagnosis is made. The injections should be repeated as the effect of the novocain diminishes after several hours. The frequency of injections depends entirely upon the clinical response to the initial and subsequent injections.

It has been felt that heat applied to the extremity and to the abdomen helped in relieving the vasospasm. Freeman, however in his studies on the effect of temperature in gangrene found that the more rapid circulation produced by heat in patients with normal blood vessels took care of the increased metabolism produced by the heat but that in patients with occlusion, the circulation may not be able to develop to the extent required by the increased tissue metabolism. Under such circumstances the discrepancy between the needs and blood supply of the tissues may actually be increased by application of heat.

In a study of the effect of temperature variations on anemic tissue Brooks and Dun

can found definite evidence that diminished temperatures prolonged the viability of the tissue deprived of adequate circulation. However they stated that further evidence must be obtained before one could definitely state that the period of viability was increased because of an alteration of metabolism in the presence of lowered temperatures.

Therefore, in the early stages of the occlusion, the collateral circulation may be enhanced and the capillary bed increased by moderate application of heat. Within several hours a maximum effect should have been obtained from the heat and if the circulation is not restored to near normal at that time then the extremity should be treated as anemic tissue and an attempt to retard the metabolism by refrigeration should be made.

In addition to the active surgical measures we feel that the vasodilator drugs help to diminish the vasospasm. Atropine sulfate given intravenously immediately and repeated subcutaneously every 4 hours thereafter is a valuable adjunct in therapy. Copalvin given by mouth every 4 hours assists in the vasodilation and also relieves the pain that may be present. If the pain is severe and persistent, then morphine and pantopon have to be used to keep the patient comfortable.

Finally in those cases in which therapy fails to re-establish an adequate circulation, amputation should be performed as soon as there is a definite line of demarcation between the normal and gangrenous tissue. If amputation is delayed, the patient becomes toxic with a febrile reaction, general malaise, loss of appetite and even delirium. A plastic type of flap amputation can be performed if one realizes that the level of ischemic necrosis of the deeper tissues is higher than the line of demarcation seen on the skin. An appreciation of this fact will lower the incidence of secondary amputations.

SUMMARY

1. Four cases of gangrene complicating fractures or fracture-dislocations about the knee have been presented. Dissection of the vessels revealed thrombosis of the main arteries in 2 cases and laceration of the main artery in the other 2 cases.

2 Anatomical dissections demonstrate that vascular complications following fractures about the knee are dependent upon the proximity of the vessels to the bones, and the restraint placed upon these vessels by the surrounding tissue

3 The therapy for the two different clinical and pathological entities of thrombosis and laceration of the main arteries has been discussed

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COMPLETE SURGICAL DIVISION OF THE PATENT DUCTUS ARTERIOSUS

A Report of Fourteen Successful Cases

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THE ductus arteriosus forms a by-pass which is essential for the circulation during fetal life but it normally undergoes closure during the neonatal period. If however the vessel remains open the individual is left with a permanent shunt between the aortic arch and the pulmonary artery. Such a communication if not too large is compatible with a long and active life but sufficient evidence has now accumulated to show that patients with this abnormality will frequently develop complications which are of considerable importance. First the shunt may divert so much blood from the peripheral circulation that the physical growth is retarded or indeed the mature individual may be stunted. Second the leak can be of such magnitude that a large volume of blood is passed through it in a useless fashion hence the work of the heart is greatly increased and the cardiac reserve is reduced even to the point of circulatory failure. Third, there may be a superimposed *Streptococcus viridans* endocarditis (or endarteritis of the pulmonary artery). Finally there are rarer complications such as aneurysmal dilatation of the ductus, rupture of the ductus, and embolism from thrombosis of the ductus. These various hazards are sufficiently serious and appear with great enough frequency to make surgical closure of a patent ductus arteriosus advisable—provided this can be accomplished with a reasonably low mortality rate.

In 1907 Munro suggested that obliteration of a persistent ductus might be performed by surgical means. This was initially attempted by Strieder (1) but for technical reasons the vessel could not be completely shut off and the patient died 4 days later. The first suc-

cessful ligation of a ductus was reported by Gross and Hubbard (4). In our early cases the restricted size of the operative field and the extremely short length of the ductus led us to simple ligation of the ductus rather than to the more dangerous procedure of dividing it. While the limitations of ligation were obvious, its shortcomings were offset by the fact that it would accomplish the desired result in most instances and that it could be completed with a negligible risk to the individual's life.

Whenever a large artery is obstructed "in continuity" by a single ligature (or closely placed ligatures) tiny crevices may be left as the wall is wrinkled and folded together—hence a small leak remains. If an effort is made to avoid this residual opening by snugging up the ligatures very tightly there is always the attendant danger of pressure erosion of the vessel wall. Such cutting action can be minimized by employment of broad materials such as linen tape or an aluminum band, but the accumulated experience of many surgeons indicates that this complication cannot be entirely abolished by using any of the substances which have yet been suggested and tried. If such a vessel is cut into (or is cut through) by its ligature, there may be subsequent (1) re-establishment of the vascular channel (2) development of a regional hematoma, or (3) fatal hemorrhage. All of these general considerations apply to the surgical closure of any large artery or vein they are also applicable to the problem of ligation of a patent ductus arteriosus. I have employed simple ligation of a ductus Botalli in 14 patients. Most of these had a perfect or highly gratifying result, but several of them obtained an incomplete closure or else the ligature partially cut through the ductal wall some days or weeks after the operation.

From the Departments of Surgery of the Peter Bent Brigham Hospital, the Children's Hospital, and the Harvard Medical School.

Fig 1

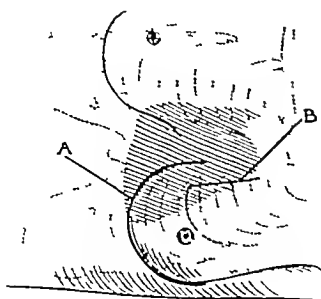


Fig 2

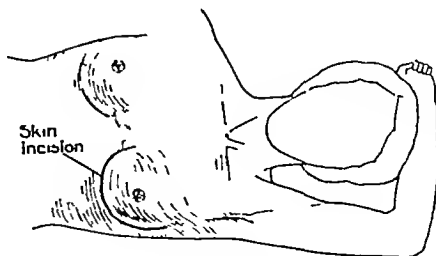


Fig 3

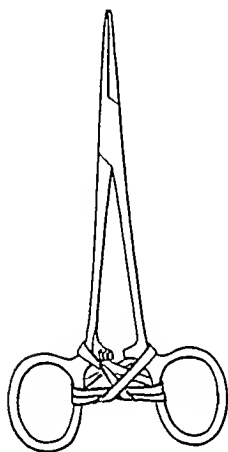


Fig 4

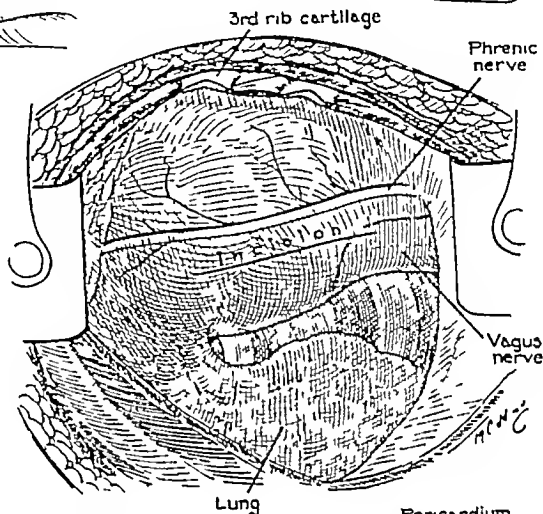


Fig 5

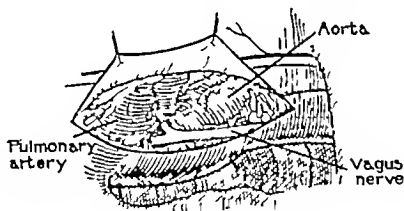


Fig 6

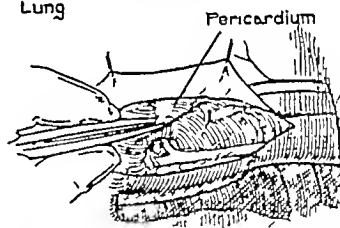


Fig 1 Position of incisions in relation to heart. A Cutaneous incision, B, Cartilage and intercostal incision

Fig 2 Cutaneous opening below breast which is subsequently turned upward

Fig 3 Method of applying rubber band on the hemostat (the ratchet is never used)

Fig 4 Chest open. Mediastinum to be opened along black line posterior to the phrenic nerve

Fig 5 Flap of parietal pleura held forward with two sutures

Fig 6 Lappet of pericardium being raised from ductus (not necessary in all cases)

In order to attain better results than had been secured by simple ligation of a patent ductus, 28 additional patients were operated upon by the following technique. The ductus was compressed with two heavy braided silk ties which were applied with a tension that would not conceivably cut the vessel wall. If the ductus happened to be soft and elastic, this step alone would be sufficient to effect a complete closure, if the ductus was thick, stiff,

and unyielding, a small pinhole opening would be left. In either type of case, "unsurfaced" cellophane (about $\frac{1}{4}$ inch wide and four layers thick) was placed over the silk ligatures and then tied (but not constricting the ductus). As shown by the work of Pearse, there is something in the cellophane which excites a regional fibrosing reaction. The contracting scar tissue compresses the ductus and gradually closes off any small fistula which might have re-

maintained at the termination of the operation. In the majority of cases this method (of ligature plus cellophane) gave a complete closure so that no murmur was ever detected after operation. In several patients a small leak was noted after operation which then disappeared in a few months. In 3 patients minimal leaks have persisted for the 1 to 3 year periods since their operations. This technique is undoubtedly an improvement over simple ligation; it carries a very low mortality rate and it will probably be quite valuable for many additional cases in the future. Its occasional failure fostered the desire to develop a perfect type of undertaking—complete division of the ductus—so that this arteriovenous type of fistula could be immediately completely and permanently shut off.

In the presence of an open ductus, the space between the aortic arch and the pulmonary artery is so narrow and the ductus is so short (4 to 6 mm.) that it is usually impossible to place two ligatures on the ductus and cut between these without great danger of having the ligatures slip off and produce fatal hemorrhage. Touroff was able to tie doubly and divide the ductus in 2 patients but such a technique should be reserved for the rare individual who has an unusually long ductus. After many unsuccessful attempts in the surgical laboratory to devise special clamps and instruments for facilitating a ductal division these were all discarded and the following procedure was adopted.

The operation herein described has now been used successfully for 14 patients. In each of these it was carried out in a very satisfactory manner. There were often anxious moments about the possible slipping of clamps, the strength of the suture material, or the fear of a sudden and uncontrollable hemorrhage but the aortic and pulmonary ends of the ductus could always be firmly and accurately closed. It is difficult to predict the percentage of patients for whom complete division can be safely employed. The experience of the operator, the breadth of exposure in the field, the smoothness of the anesthesia, the length of the ductus, etc. are all factors which must be carefully weighed before the attempting of ductal division in any particular instance. If

however conditions are such that complete division of the vessel can be accomplished, then the surgeon may feel assured that he has performed the best type of correction for this cardiovascular abnormality. Since it has been possible to accomplish a complete ductal division in my last 14 consecutive cases, I am led to believe that only rarely will it be necessary in the future to revert to the less desirable operation of ligation.

OPERATIVE TECHNIQUE FOR DUCTUS DIVISION

Exposure of the superior mediastinum and great vessels has been described at some length in previous communications (2, 3). Hence only a brief summary will be given here regarding opening of the chest and approach to the ductus region. A curved incision is made below the left breast so that the local skin and the entire breast can be turned outward and upward. The pectoral muscles are severed at their attachments to the thorax. The left pleural cavity is entered in the 3d intercostal space; the intercostal muscles should be severed from the sternal border almost to the angle of the ribs. The 3d and 4th costal cartilages are cut so that these ribs can be retracted upward. As the lung collapses away the heart and superior mediastinum can be viewed from their left lateral aspect. The parietal pleura which covers the mediastinum is opened above the lung root. This incision is carried well up over the aortic arch. It is situated parallel to and midway between the phrenic and vagus nerves. Great care should be taken to identify and isolate the left recurrent laryngeal nerve so that it will not be injured during the subsequent dissection or manipulations. In some individuals lymph nodes will obscure the field and must be dissected away before the underlying structures can be adequately viewed.

Palpation of the great vessels now shows that there is a marked thrill over the pulmonary artery which is widely transmitted to regional structures. The thrill is more intense during systole and tends to die off during diastole. While it can be felt over the entire pulmonary artery it is most prominent just opposite the opening of the ductus. Not uncommonly the exact position of the ductus is

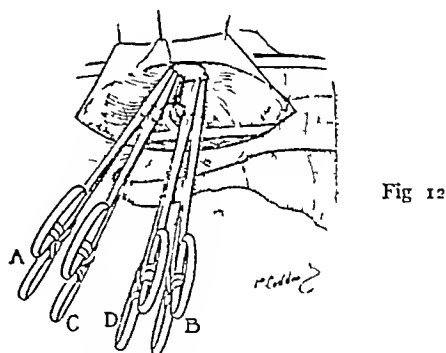
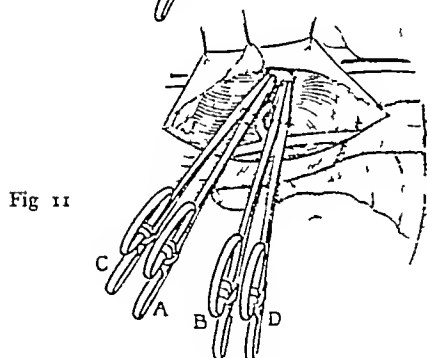
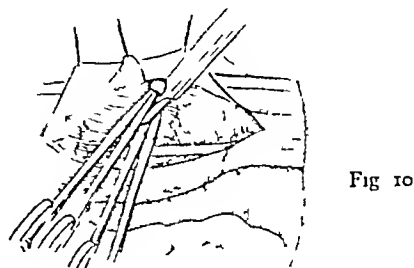
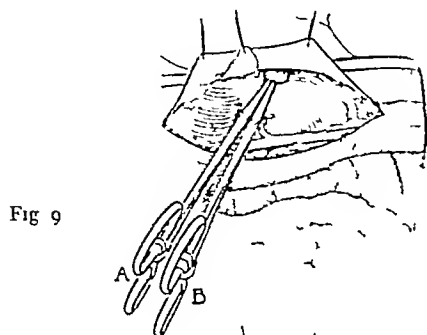
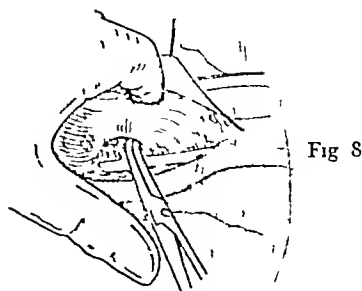
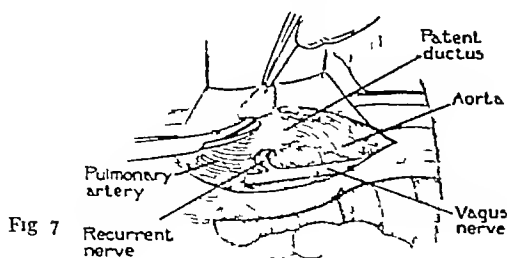


Fig 7 Lappet of pericardium being dissected off of ductus and pulled forward

Fig 8 Ductus being bluntly freed around its entire periphery

Fig 9 Two clamps on ductus (held in place only by tension of rubber bands on the handles)

Fig 10 Four clamps applied Ductus being cut with scalpel between two middle clamps

Fig 11 Ductus divided Two clamps remain on either end of the vessel To obtain more length of vessel to work upon, Clamp A will be shifted proximal to C and Clamp B will be shifted proximal to D

Fig 12 Clamps shifted

at first obscure because overlying fat and areolar tissue cover over and hide it Under such circumstances, a finger-tip can be pushed posteromedially into various parts of the groove between the aortic arch and pulmonary artery If steady and firm pressure does not change the regional thrill, the finger is then moved to another part of the groove and pres-

sure is reapplied This topical examination is repeated in different areas until a point is found where the pressure will compress the underlying ductus and thereby abolish the thrill in the pulmonary artery Finding the ductus can also be facilitated by tracing the recurrent laryngeal nerve downward, since this passes lateral and then posterior to the ductus

After the ductus has been identified, the fat is slowly and carefully cleared from its anterior and lateral surfaces. The anteromedial part of the dissection can usually be accomplished by delicately placing the point of a half length clamp between the aortic arch and the pulmonary artery and gently spreading the jaws apart. The instrument is then passed deeper into the slit thus made and the tissues are further bluntly dissected. Occasionally there is a rather fibrous web stretching between the pulmonary artery and the medial surface of the aortic arch the fibers of which are best severed with small-bladed scissors. The medial border of the ductus deserves the utmost care. It can be bluntly separated from the underlying left main bronchus by a right angle clamp. Very delicate dissection must be employed since this medial wall may be thinner than one anticipates. If the vessel is accidentally torn exsanguinating hemorrhage can occur with alarming rapidity. (In only 1 of 56 surgically treated cases of our series has there been any bleeding from the ductus wall. While there was an immediate and serious loss of blood the rent could be closed and the patient survived.) The literature contains several reports of rupture of a ductus during operation giving rise to fatal hemorrhage on the table. Consequently one should be exceedingly slow and cautious and gentle while dissecting the vessel away from the surrounding structures.

In some subjects the pericardium has a very high reflection and a pannus of it overlies the ductus. This flap of pericardium should be freed from the ductus and the adjacent pulmonary artery by sharp and blunt dissection so that it can be turned forward out of the way. Every effort should be made to keep the pericardial envelope intact because an opening in it allows continual escape of frothy fluid which runs down on the operative field.

The ductus must have more than a narrow zone of clearing around its periphery. It should be widely freed from structures which lie against its posterior and medial surfaces. Subsequent steps will demand considerable mobility of the medial ductal wall as well as the adjacent medial surfaces of the aortic arch and pulmonary artery. Hence it is imperative that these places be cleared as much as

possible before the surgeon attempts actual division of the ductus.

Two clamps are now placed directly on the ductus as shown in Figure 9. It has been found that standard straight hemostats about 5½ inches in length will have jaws of optimum size. (The base of the jaws should be ground off on both sides so that these surfaces will be nearly parallel.) It is important to employ clamps which are either new or which have been well cared for so that no undue wiggling or side motion occurs at the hinge which would allow side-play of the jaws. A clamp should never be closed so that the handle ratchet becomes engaged since this amount of pressure will produce crushing injury to the ductal wall and will probably lead to subsequent sloughing. It has been satisfactory to place a new rubber band around the handle as shown in Figure 3 so that the instrument is held in place solely by the tension of this rubber band. The elastic band can be made sufficiently taut so that the clamp will not slip off the ductus wall and yet it will not have sufficient pressure to crush the vessel.

When two clamps are applied (Fig. 9) they appear to take up all of the available room between the aortic arch and the pulmonary artery. However it is now possible to squeeze in an additional clamp on the aortic side and another one on the pulmonary side so that four clamps are in position (Fig. 10). The outside clamps will be found to ride up on the pulmonary artery and aorta, respectively. With a small scalpel, the ductus is now divided between the two middle clamps, so that two instruments remain on the pulmonary end and two on the aortic end of the ductus (Fig. 11). All of these clamps must be left free in the field so that they can slide with the respiratory motions of the mediastinum and with the beating of the great vessels. They must not be all wed to flop downward nor should they become impinged against the chest wall. They must not be struck by the operator or assistant's hands. Any such pressure, angulation or jarring of the clamps may dislodge them from the ductus.

It is possible but clamps could be applied and the ratchet closed without causing crushing injury of any importance. However I have seen clamps so used the danger by using the "lock" bands on the top has been.

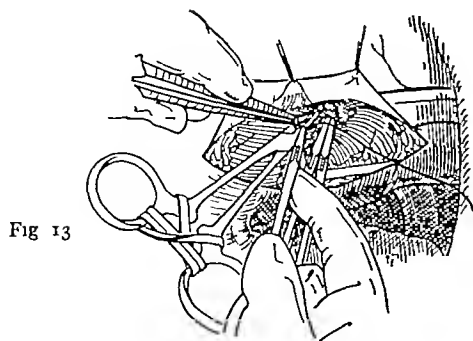


Fig 13

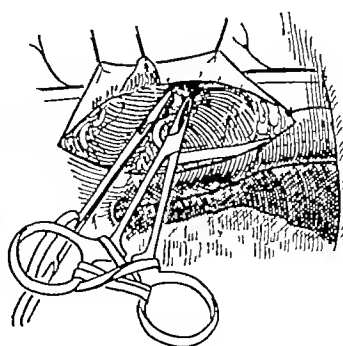


Fig 15

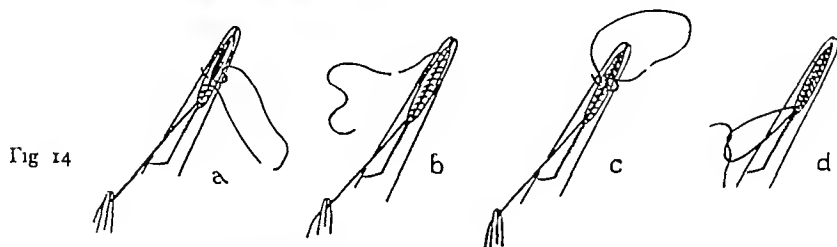


Fig 14

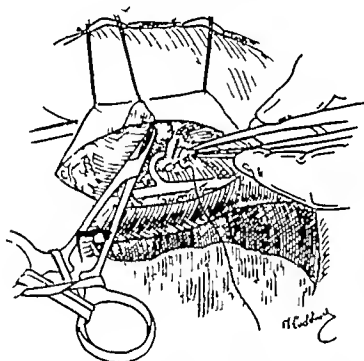


Fig 16

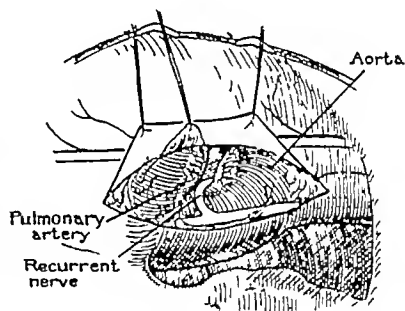


Fig 17

Fig 13 Distal clamp removed from pulmonic end. Single clamp remains for hemostasis. Beginning suture of the presenting cuff (formed by removal of distal clamp).

Fig 14 Details of cuff suture. a, Continuous fine silk suture. b, Row of suture completed. c, Suture continued back—making an overlapping closure. d, Suture being tied.

Fig 15 Distal clamp has been removed from aortic end (the cuff will be treated as in 14 a d).

Fig 16 Hemostatic (proximal) clamp taken off of aortic end. Second row of sutures being started to bring together adventitia (over the first suture line).

Fig 17 Remaining clamp off of pulmonic end, and adventitial suture completed. (This gives two rows of suture on aortic end and two on the pulmonary end.)

The recurrent laryngeal nerve must be kept constantly in mind and protected from injury by the hemostats or sutures. It can be freed readily from its bed and can be displaced downward away from the ductus for 4 or 5 millimeters. When the hemostats are placed on the ductus, their tips must not catch the

inferior cardiac nerve which arises from the recurrent laryngeal nerve. Furthermore, the jaws of the hemostats must be placed on the ductus in such a way that they cannot back off, on the other hand they must not protrude so far inward that they pierce the underlying left main bronchus.

After the ductus has been severed, the distal clamp on the pulmonary end is removed. This leaves a small 2 or 3 millimeter cuff which can be sewed over and over with a continuous fine silk stitch. If by any chance the removal of the distal clamp leaves too short a cuff additional length of the cuff can be obtained by putting a clamp proximal to the remaining clamp and then removing this latter (Figs. 11 and 12). After 10 to 15 bites are taken in the ductal end (Fig. 14) the stitch is then run back over the cuff so as to make a basket like or interlacing closure. It is highly important to use fine silk which is waxed or oiled so that it will slip easily through the vessel wall without tearing it. Deknatel No. 00000 (size B) has a high tensile strength combined with a small diameter which makes it a superb material for this delicate task. It must be mounted on an atraumatic needle. In all of the present cases a small curved non-cutting (Deknatel eyeless needle No. 9) needle was found to be perfect for the job.

The aortic end of the ductus is now treated. The distal clamp is removed, the proximal one being left for hemostasis, and the cuff of tissue is whipped over and over as previously described for the pulmonary end. It will be found that if the pulmonary end has been treated first—and hence one of its clamps is out of the way—more room will be obtained to facilitate work on the aortic side, where it is highly important to have a tight and accurate closure.

After the first row of aortic sutures has been placed the single remaining clamp is slowly removed. If the first line of sutures has been properly taken there will be no bleeding. If however some oozing does occur a sponge should be pressed directly over the line of suture for 3 or 4 minutes until clotting occurs. When the field is dry a second suture line (Fig. 16) is made the adventitia being brought together with a continuous fine silk suture to cover and support the first row of stitches.

Finally the remaining clamp is removed from the pulmonary end of the ductus and a second layer of continuous sutures is placed in order to bring together its adventitial structures. These steps have now produced a double closure of the aortic and of the pulmonary

sides of the ductus. (In the last 8 cases here reported great care was used in the placing of the first layer of sutures on the pulmonary artery and the aorta the second layers of sutures were omitted. The results have been completely satisfactory.)

The mediastinum is covered by the bringing together of the edges of its parietal pleura with interrupted silk sutures. Repair of the bony cage and the overlying wound can be accomplished rapidly but if time is spent in a meticulous closure, the patient will have a smoother and more satisfactory postoperative course. A rather stiff rubber urethral catheter (No. 16 or 18 French) with several holes cut in its tip is led down into the posterior portion of the pleural cavity and is brought out through the chest wound. The ends of the 10 and 3d costal cartilages are now repaired with ligatures, preferably of silk, so that any delay in the healing of the cartilages will not allow the ends to override. The 3d and 4th ribs are brought together with 4 or 5 encircling, heavy chromic catgut sutures. The intercostal muscles are approximated with a continuous chromic catgut suture. The pectoral muscles are sewed down to the chest wall, and the anterior pectoral fascia is repaired with interrupted sutures, preferably of fine silk. The superficial fascia is brought together and then the subcutaneous fat is closed with several layers of fine sutures. In order to obtain a hair-line cutaneous scar—which will not subsequently spread—the corium must be accurately approximated and no fat must be allowed to protrude up between its edges. This is best accomplished with interrupted fine, white silk stitches. Finally the epidermis is brought together with a continuous corium suture of dermic this latter is left in place from 8 to 12 days before removal. This gives an admirable skin closure which leaves no stitch marks.

Just before the skin is brought together suction is applied to the catheter which had been previously placed in the chest. In this way all the air is withdrawn and the catheter is then pulled out. Expansion of the lung in this way causes less postoperative reaction than does expansion of it by a high positive pressure through the anesthesia machine.

REPORT OF CASES

The technique which has been set forth in the preceding section has now been used for 117 human subjects. These varied in age from 2 to 72 years. There have been no fatalities or important complications. The postoperative hospitalization has averaged 15 days; the earlier patients were kept a longer period because of interest in their cases, but more recently the individuals have been discharged on the 8th or 9th day. Two patients had a superimposed subacute bacterial endocarditis (*Streptococcus viridans*) prior to operation. Division of the ductus in these cases was done with considerable expectation of averting that infection in the ductal wall would allow the sutures to slough and lead to fatal hemorrhage. However, these operations were completed without any more difficulty than was encountered in the uninfected cases.

SUMMARY

Ligation or complete ductus arteriosus has produced satisfactory closure in most of the

117 cases in which it was used as the only method of obliterating the shunt. Better results were obtained in another series of 25 patients in whom the ductus was ligated and was afterwards wrapped with cellophane to promote permanent closure. What this latter method has been an improvement over the earlier procedure, at least in a few instances, to produce absolute closure of the ductus. A new technique for complete division of the ductus, which secures permanent complete closure of this vessel, has been performed in 12 patients, 10 of whom had a superimposed *Streptococcus viridans* endocarditis. All the patients have recovered and 10 of whom had no important complications from the operation undertaken.

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THE IMPORTANCE OF FOCAL INFECTION IN OBSTETRICS

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AFTER an acute local inflammation has subsided the bacteria that caused it frequently persist in the local tissues, where they either remain inactive or produce a chronic local inflammation of latent mild or moderate character depending upon the degree of local resistance in the infected tissues. Whether the infecting germs in a chronic local infection confine their activities to the tissues they inhabit or whether they, their soluble toxins are carried by the blood stream to other tissues, more or less dependent to a great extent upon the general resistance of the patient. When bodily resistance is high, foci of infection may exist for years without producing disease elsewhere. Lowered general resistance however enables an infecting organism in a primary focus of infection to form metastases or secondary foci of infection outside of the tissues in that focus. This is known as focal infection. Among the factors that lower general resistance are fatigue, unhygienic living, acute and chronic illnesses, chilling hemorrhage pregnancy and trauma—including the trauma of childbirth and of operations.

A number of obstetricians conclude from clinical observation that many of the accidents, diseases and complications of pregnancy are the result of focal infection. They consequently emphasize the importance of removing all foci of infection that are accessible and removable. Most obstetricians in my opinion, direct their attention chiefly to the pelvic cavity and ignore to a great extent infection in the upper respiratory tract.

The various conditions that obstetricians believe can be caused by focal infection will be considered separately.

Abortion. Bland and First La Vake (24) Mosher Pierrepont Schumann, and Talbot (4) recognize focal infection as one of the

causes of abortion. Talbot (44) explains the process as the result of hematogenous infection of the maternal blood vessels of the placental site by bacterial emboli from a focus of infection. The process of infarct formation he shows, destroys the function of just as much of the placental tissue as is involved by the thrombotic process. Thus a portion of the feeding surface for the fetus is taken away. In the early months of pregnancy when the total placental area is small the infarcted area may be relatively large. When this proportion is large enough it results in the termination of the life of the fetus which in turn results later in miscarriage or the throwing off of the dead fetus. This explains the greater incidence of miscarriage within the first 3 months of pregnancy.

The toxemias of pregnancy. Focal infection is regarded as one of the causes of the toxemias of pregnancy by Adair Bland and First De Lee Evers, Fowler La Vake (24) Mosher Pierrepont Reed and Cooley and Talbot (45). The last named has presented considerable evidence both experimental and clinical showing that toxemia of pregnancy is primarily due to bacterial invasion of the organs of the pregnant woman from foci of chronic infection. De Lee stated that focal infection may be the underlying cause of a gestosis and that removal of foci of infection has sometimes worked a cure.

Mackenty observed that obstetricians are inclining to the belief backed by considerable clinical evidence that the toxic vomiting of pregnancy is in some way related, directly or indirectly to toxic focal disease. The association of the pernicious vomiting of pregnancy with foci of infection has been referred to by Bland and First Evers Reed and Cooley and Talbot (46).

Eclampsia and pre-eclamptic toxemia are believed by Adair Mosher Pierrepont and Talbot (47) to be due to focal infection.

Mackenty quoted the statement, made to him by an obstetrician whose experience has been unusually large, that since medicine and surgery had been active in the elimination of toxic foci, eclampsia has been greatly reduced.

The nephritis of pregnancy The part played by focal infection in the etiology of nephritis associated with pregnancy is mentioned by Alport, Bland and First, Evers, Mosher, Randall, Stieglitz, and Talbot (45).

Pyelitis during pregnancy Many authors, according to Kretschmer, consider that a focus of infection is important in the causation of the pyelitis of pregnancy. Bland and First, Danforth, Randall, Reed and Cooley, and Talbot (44, 46) likewise direct attention to focal infection as an etiological factor.

Disorders of the placenta Young believed that premature separation of the placenta is in many instances due to a thrombosis of the uterine and ovarian vessels, causing a hemorrhage and a separation of the placenta from the damming back of blood. La Vake (24) goes a step further and postulates infection or bacterial toxins as a possible source of the thrombosis, giving evidence of severe accidental hemorrhage being due to focal infection. He believes that the clearing up of all foci of infection in pregnant women, as far as it is possible or expedient, may aid in reducing the incidence of accidental hemorrhage.

Talbot (45) is convinced that many placental infarcts are due to hematogenous infection of the maternal vessels of the placental site. He has observed more than 50 cases in which a bleeding spell was recorded upon the placenta by contemporaneous white infarction on its edge or by cessation of growth. Many of these attacks of bleeding were associated with demonstrable acute infection in the mouth and throat. Talbot's clinical observations suggest that the acute infection causes the bleeding from the placental site, and that the white infarct on the edge of the placenta is the result of this pathological lesion. It seems to him justified to make the deduction from clinical and laboratory evidence that many placental infarcts are evidence of blood-borne infection from the point of entrance in the head to the uterine tissues immediately beneath the placenta (45).

The infarcted area in the early months of pregnancy may occur in the middle of the placenta or on its edge. When on its edge, the damage done prevents the further enlargement of the placenta at that point. When the concentric enlargement of the placenta is thus inhibited, there is the compensatory growth on the undamaged edge of the placenta to supply the needs of the growing fetus. This results in the asymmetrical type of placenta (44). When the original attachment of the ovum is low enough in the uterus, an infarct in the early months of pregnancy may drive the compensating growth of the placenta downward, with the result that low-attached placentas, marginal and complete placenta praevias may result (47). Talbot (44) says that a certain proportion of this class of placenta previa are preventable by removing known foci of chronic sepsis before they do harm. Infection of the whole edge of the placental site he believes may be the determining factor in the so called placenta circumvallata or its modifications.

In the experience of Bland and First and of Mosher, foci of infection may predispose to premature separation of the placenta.

Puerperal sepsis The old idea in regard to puerperal sepsis was that the infecting germs are introduced by the finger or instrument of the obstetrician or through contact of the vulva with unclean hands, linen, or other objects.

Of the avenues of internal infection, one is the presence in the birth canal prior to labor of a streptococcus which is able to infect when the patient's general resistance is lowered by the shock, hemorrhage, exhaustion, and fatigue of delivery and when the local resistance of the birth canal is lowered by the trauma produced.

Another avenue of internal infection is the direct transmission to the uterus of bacteria from the respiratory tract of an individual attending the confinement.

A third cause of puerperal sepsis of internal origin—one insufficiently recognized by the profession at large—is focal infection.

As long as 40 years ago Ahlfeld called attention to the fact that a woman occasionally becomes infected from bacteria which are transported to the genital canal via the blood.

stream from a distant site of suppuration such as infected tonsils, lungs or breast. De Lee likewise refers to the inoculation of the patient by herself with bacteria carried from a focus of suppuration. It is undoubtedly true according to Schumann, that a definite proportion of cases of puerperal sepsis is traceable to an autogenous infection. Beck, Bland and First, D. Colebrook, Condon, Evers, Irving, Lancefield and Hare, Lash, La Vake (24), Ramsey and Pierce, Rose, White et al. and Woodward and Gardner concurred.

Breast abscess. Talbot (44) regards breast abscess as an infection of hematogenous origin and a manifestation of chronic sepsis.

Among the etiological factors concerned with the development of breast abscess, Dippel and Johnston likewise cite foci of infection. They say that the association of breast abscesses with infection elsewhere in the body such as the uterus, urinary tract, tooth, finger or upper respiratory tract, occurs and culturally shows the same organisms too often to be merely coincidental. Harris reported a case in which the breast milk and dental foci contained the same organism and in which the infection in the milk cleared up on the removal of the infected teeth. He also described a case of breast abscess of 2 years' duration which healed in a week after dental infections were removed.

Phlebitis. Chronic sepsis is regarded by Talbot (44) as the etiological factor in phlebitis. La Vake's (25) experience has indicated to him that dental infection concealed or open, means an increased chance of postpartum phlebitis.

The removal of foci of infection. At no time should operation upon a focus of infection be regarded lightly irrespective of pregnancy. The operative trauma by lowering bodily resistance may even produce a spread of the infection. Such simple procedures as tonsillectomy and dental extraction have precipitated disease of the heart, kidneys, joints and eyes.

It is possible, however, to minimize the dangers of such an operation by the exercise of extreme gentleness by not removing more than one tooth at a sitting by preparing a patient prior to operation with a view to raising her resistance by attention to postoperative

care by preoperative autogenous vaccination and by administering a sulfonamide for 3 days before and 3 days after operation.

In attempting to rid a patient of infected tissue one must remove all such tissue. Infected tonsillar remnants and broken-off infected tooth apices are as dangerous as diseased tonsils and abscessed teeth. Moreover, secondary foci should not be neglected for they can keep up the focal infection.

Operative care on a focus of infection during pregnancy. It is the general opinion, according to Bland and First, that there is no danger associated with oral surgical therapy, including extractions, during pregnancy, except in a very limited number of women who exhibit a tendency to miscarry. In Ziakins' experience, the removal of dental foci caused no increase in the number of miscarriages, abortions, or stillbirths. From his records of the dental operations on 720 pregnant women he concludes that dental treatment for pregnant women may be approached with no more hesitation than for other types of patients and that dental operations may be performed without ill effects during any month of pregnancy.

La Vake (25) says that obstetrically it is more safe to eradicate at once all definite foci of infection than to wait. He believes that pregnant women stand all anesthetics well, subject to the individual idiosyncrasies of the nonpregnant and that they stand operation well so long as the infection does not supervene or a cause of high temperature does not operate. In eradicating foci of infection he warns that we must drain with care to avoid, if possible, severe vaccination reaction.

Bubis also believes that less harm will be done by treating these foci during pregnancy than may occur if they are neglected until after childbirth.

Talbot (48) however, thinks it is not safe to take a chance on increasing the activity of sepsis before the beginning of the fourth month. He likewise believes that chronic sepsis should not be disturbed in the presence of toxemia of pregnancy. He regards the safest time to be between the fourth and seventh months of pregnancy. He prefers however to remove foci of chronic infection either before or between pregnancies.

Neglect of the purely bacterial focus of infection. Obstetricians share with otolaryngologists and most physicians a serious misconception of a focus of infection (34) doubtless due to Billings' definition of it as "a circumscribed area of tissue infected with pathogenic organisms." I would stress the infecting organisms, rather than the infected tissue, and would define a focus of infection as "infecting bacteria, pathogenic for their host and producing toxins inimicable to him, which have their habitat in a more or less circumscribed area." Thus defined, a focus of infection in the upper respiratory tract is never removed by the surgeon's knife, which merely extirpates infected tissue and drains infected cavities. After a tonsillectomy, for instance, the infecting bacteria may still be found in the tonsillar fossae, in the nasopharynx, and on the faucial pillars and adjacent tissues, and, after sinus drainage, in the sinus, nares, and nasopharynx, where they remain and multiply and elaborate toxins, until they are overcome by the patient's defensive forces (35, 36, 37). Their destruction, however, may follow the operation spontaneously, especially when attention is given to hygienic measures. In most cases, however, the writer has found it necessary to stimulate antibody production artificially by administering a potent autogenous vaccine (37, 38, 39), made from pathogen-selective cultures (40, 40, 41, 42), which are those most likely to contain the infecting germ. As this vaccine is very potent, it must be given extremely carefully in the appropriate dosage for the individual patient (38). Bernstine and his associates (5, 6, 7), however, have reported favorable results from stock vaccine.

The disappointing results experienced by most obstetricians in prophylactic immunization are due, in my opinion, to failure to discover, treat, and culture all foci of infection, failure to include the infecting organism and its soluble exotoxins in the vaccine, and failure to administer the vaccine properly.

SUMMARY

Focal infection is a frequent cause of many of the accidents, diseases, and complications of pregnancy, labor, and the puerperium.

Great caution should be observed in removing infected tissue at a focus of infection at all times and especially during pregnancy.

Removal of infected tissue at a focus of infection frequently fails to eradicate the infecting organisms, which may continue to multiply and to elaborate toxins and thus keep up the focal infection.

The elimination of these microbes may require artificial stimulation of antibody production by the careful administration of a potent vaccine containing the infecting bacteria and their soluble exotoxins.

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NUTRITIONAL DEFICIENCY IN THE ETIOLOGY OF MENORRHAGIA, METRORRHAGIA, CYSTIC MASTITIS, AND PREMENSTRUAL TENSION

II Further Observations on Treatment with the Vitamin B Complex

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OBSERVATIONS made 2 years ago that the liver loses its ability to inactivate estrogen in vitamin B complex deficiency led us to investigate the relation of nutritional deficiency to clinical syndromes associated with excess estrogen

When a pellet of estrone or estradiol is implanted in the spleen of a castrate female rat, the absorbed estrogen must pass first through the liver via the portal circulation (3, 4) On a complete diet such an animal remains anestrus, on a vitamin B complex free diet it goes into continuous estrus (6) Brewer's yeast restores the anestrus state, subsequent depletion again leads to estrus (7) The flow of estrogen through the liver can be controlled at will, by withholding the B vitamins or by restoring them to the diet The same phenomenon occurs if, instead of implanting a pellet, one ovary is transplanted to the spleen and the other is removed (9) It occurs in the absence of detectable gross or histological lesions in the liver (7)

When, however, pellets of testosterone propionate are implanted in the spleens of castrate male rats, there is no significant difference in the weights of prostates and seminal vesicles in animals on a B free or in those on a yeast supplemented diet (8) Estrogen ceases to be inactivated in vitamin B complex deficiency while androgen continues to be inactivated, thus a serious alteration must occur in the estrogen-androgen equilibrium

We undertook to find out whether patients with signs and symptoms of nutritional deficiency had menorrhagia, metrorrhagia, painful breasts, pre-

menstrual tension, or a combination of these And patients who presented one or more of these conditions were investigated as to their nutritional status A striking correlation was found, and treatment with vitamin B complex was instituted

Preliminary observations previously reported on 29 patients (5) have now been extended to include studies on 104 patients, of whom 70 were treated with various preparations of vitamin B complex

Lest it be assumed that the phenomena related to nutritional deficiency to be described are characteristic only of clinic patients in certain localities, it should be pointed out that more than half the treated patients were private ones living in New York, Ohio, California, and Oregon These observations were made by the 3 of us, each working independently in a different city

Of 39 patients who were observed primarily because of the presence of lesions of nutritional deficiency, 37 had a history of menorrhagia, metrorrhagia, painful breasts, premenstrual tension, or a combination of these Of 52 patients whose main complaint was one of the latter conditions, and who were examined for evidences of nutritional deficiency, every one had signs or symptoms or both, characteristic of B avitaminosis, and these signs and symptoms improved on vitamin B therapy concomitant with improvement in the gynecological complaint Glossitis and cheilosis were common but not always present

The response to vitamin B complex therapy in these patients was usually prompt and often dramatic Some of the patients showed only moderate improvement on oral therapy, as impairment of absorption and utilization occurs frequently in nutritional deficiency, these patients were given parenteral therapy in addition With the latter, striking improvement, especially in premenstrual tension and in painful breasts, often occurred in as little as a few hours to at most a day or two

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TABLE I.—SUMMARY OF CLINICAL FINDINGS AND RESULTS OF TREATMENT WITH VITAMIN B COMPLEX IN MENORRHAGIA, METRORRHAGIA, CYSTIC MASTITIS, AND PREMENSTRUAL TENSION

Patient Age	Complaints and associated conditions	Duration	Major indications for treatment	Treatment	Response	Results	Comments
1 20	Menorrhagia, few days	3 yr	Uterus	Oral B complex	no	Clots in blood, subsequent periods 3, 4 and 5 days, normal size	
2 40	Menorrhagia, few days, tension, blood clots	3 yr	Obesity, chloasma, anemia, hypertension	Oral and parenteral complex	no	All signs of B deficiency healed except (and at this time) normal periods, usually 5 days. Premenstrual tension cleared up on parenteral therapy	Examination had been related to treatment therapy, but possibly on B complex. Clots disappeared rapidly in one
3 30	Alternating menorrhagia and amenorrhea	—	Clots in	Oral B complex	10	Clots in blood, normal periods and days	
4 30	Menorrhagia, no blood clots	no	Uterus, anemia, premenstrual tension	Oral B complex	6	As premenstrual after 3 of longer cycle for clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots	By examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots
5 40	Menorrhagia, few days, tension, blood clots, anemia	many	Uterus, anemia, chloasma, hypertension, premenstrual tension, anemia, etc.	Oral and parenteral complex	no	Uterus normal, blood clots cleared up, 3 days, normal periods, 3-4 days' clots	Examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots
6 30	Menorrhagia, few days, tension, blood clots, anemia	3 yr	Uterus, anemia, chloasma, hypertension, premenstrual tension, anemia, etc.	Oral and parenteral complex	no	Uterus normal, blood clots cleared up, 3 days, normal periods, 3-4 days' clots	Examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots
7 30	Menorrhagia, few days, tension, blood clots, anemia	3 yr	Uterus, anemia, chloasma, hypertension, premenstrual tension, anemia, etc.	Oral and parenteral complex	no	Uterus normal, blood clots cleared up, 3 days, normal periods, 3-4 days' clots	Examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots
8 30	Menorrhagia, few days, tension, blood clots, anemia	3 yr	Uterus, anemia, chloasma, hypertension, premenstrual tension, anemia, etc.	Oral and parenteral complex	no	Uterus normal, blood clots cleared up, 3 days, normal periods, 3-4 days' clots	Examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots
9 30	Menorrhagia, few days, tension, blood clots, anemia	3 yr	Uterus, anemia, chloasma, hypertension, premenstrual tension, anemia, etc.	Oral and parenteral complex	no	Uterus normal, blood clots cleared up, 3 days, normal periods, 3-4 days' clots	Examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots
10 30	Menorrhagia, few days, tension, blood clots, anemia	3 yr	Uterus, anemia, chloasma, hypertension, premenstrual tension, anemia, etc.	Oral and parenteral complex	no	Uterus normal, blood clots cleared up, 3 days, normal periods, 3-4 days' clots	Examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots
11 30	Menorrhagia, few days, tension, blood clots, anemia	3 yr	Uterus, anemia, chloasma, hypertension, premenstrual tension, anemia, etc.	Oral and parenteral complex	no	Uterus normal, blood clots cleared up, 3 days, normal periods, 3-4 days' clots	Examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots
12 30	Menorrhagia, few days, tension, blood clots, anemia	3 yr	Uterus, anemia, chloasma, hypertension, premenstrual tension, anemia, etc.	Oral and parenteral complex	no	Uterus normal, blood clots cleared up, 3 days, normal periods, 3-4 days' clots	Examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots
13 30	Menorrhagia, few days, tension, blood clots, anemia	3 yr	Uterus, anemia, chloasma, hypertension, premenstrual tension, anemia, etc.	Oral and parenteral complex	no	Uterus normal, blood clots cleared up, 3 days, normal periods, 3-4 days' clots	Examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots
14 30	Menorrhagia, few days, tension, blood clots, anemia	3 yr	Uterus, anemia, chloasma, hypertension, premenstrual tension, anemia, etc.	Oral and parenteral complex	no	Uterus normal, blood clots cleared up, 3 days, normal periods, 3-4 days' clots	Examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots
15 30	Menorrhagia, few days, tension, blood clots, anemia	3 yr	Uterus, anemia, chloasma, hypertension, premenstrual tension, anemia, etc.	Oral and parenteral complex	no	Uterus normal, blood clots cleared up, 3 days, normal periods, 3-4 days' clots	Examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots
16 30	Menorrhagia, few days, tension, blood clots, anemia	3 yr	Uterus, anemia, chloasma, hypertension, premenstrual tension, anemia, etc.	Oral and parenteral complex	no	Uterus normal, blood clots cleared up, 3 days, normal periods, 3-4 days' clots	Examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots
17 30	Menorrhagia, few days, tension, blood clots, anemia	3 yr	Uterus, anemia, chloasma, hypertension, premenstrual tension, anemia, etc.	Oral and parenteral complex	no	Uterus normal, blood clots cleared up, 3 days, normal periods, 3-4 days' clots	Examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots
18 30	Menorrhagia, few days, tension, blood clots, anemia	3 yr	Uterus, anemia, chloasma, hypertension, premenstrual tension, anemia, etc.	Oral and parenteral complex	no	Uterus normal, blood clots cleared up, 3 days, normal periods, 3-4 days' clots	Examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots
19 30	Menorrhagia, few days, tension, blood clots, anemia	3 yr	Uterus, anemia, chloasma, hypertension, premenstrual tension, anemia, etc.	Oral and parenteral complex	no	Uterus normal, blood clots cleared up, 3 days, normal periods, 3-4 days' clots	Examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots
20 30	Menorrhagia, few days, tension, blood clots, anemia	3 yr	Uterus, anemia, chloasma, hypertension, premenstrual tension, anemia, etc.	Oral and parenteral complex	no	Uterus normal, blood clots cleared up, 3 days, normal periods, 3-4 days' clots	Examination under examination after 10 of clots cleared up, 3 days, only 1 day's normal periods, 3-4 days' clots

TABLE I—SUMMARY OF CLINICAL FINDINGS AND RESULTS OF TREATMENT WITH VITAMIN B COMPLEX IN MENORRHAGIA, MLTORRHAGIA, CYSTIC MASTITIS, AND PREMENSTRUAL TENSION—Continued

No Patient Age	Gynecologic and associated disorders	Duration	Major indications of nutritional deficiency	Treatment	Duration	Result	Comment
14 R P 26	Premenstrual tension cystic mastitis	2 yr	Glossitis cheilosis	Oral B complex	5 mo	Moderate improvement in tension and breast tenderness	Glossitis and cheilosis healed previously susceptible to subburn—tanned first time in her memory after oral B complex
14 W 15	Menometrorrhagia since menarche	4½ yr	Lingual edema severe gingivitis seborrhea alae nasi	Oral and parenteral B complex	2 mo	Complete regression of mastitis no premenstrual tension in 2 periods	Loss of 4 in. in circumference of bust and 1½ in. in hips weight stationary at 112 lb
13 A S 35	Menorrhagia severe premenstrual tension painful breasts	Many yr	Lingual edema severe gingivitis seborrhea alae nasi	Oral B complex	4 mo	4 successive normal periods 4-5 days duration no intermenstrual spotting	Facial acne present since menarche—premenstrual exacerbations previous dietary therapy for acne further deteriorated nutritional status acne almost completely cleared up on B complex, vitaminotic lesions healed rapidly
14 M C 34	Cystic mastitis cystic fibroma right breast premenstrual tension	More than 10 yr	Mild glossitis and cheilosis recurrent vesicles oral mucous membrane seborrhea alae nasi cutaneous hypersthesia	Oral and parenteral B complex	6 mo	Diminution in menstrual flow subsequent periods 6 5 4 3 3 3 days duration complete subsidence of premenstrual tension and breast tenderness	Striking decrease in fat deposition about hips thighs and abdomen before any loss in weight occurred cutaneous hypersthesia disappeared marked improvement in tolerance for and response to thyroid maintained subsequently on oral B complex alone
14 J S 47	Severe premenstrual tension 2 previous episodes of menorrhagia	More than 10 yr	Mild glossitis and cheilosis recurrent vesicles oral mucous membrane seborrhea alae nasi cutaneous hypersthesia	Oral and parenteral B complex	5 mo	Striking improvement in avitaminotic lesions and symptoms no breast tenderness or premenstrual tension in 5 successive periods	Complete regression of mass 3 by 3 by 1 cm in right breast in 3 mos Maintained subsequently on oral B complex alone
15 J S 47	Severe premenstrual tension 2 previous episodes of menorrhagia	Indefinite	Glossitis insomnolence impairment of memory for recent events extreme irritability pain in legs	Oral B complex	6 wk 3½ mo	No improvement Rapid and complete subsidence of all symptoms	Marked relief of persistent pain in legs of many yrs' duration refractory to other therapy
16 N S 25	Premenstrual tension dysmenorrhea	Few yr	None except extreme irritability premenstrual acne	Oral B complex	3 mo	Marked improvement in general health no premenstrual tension or dysmenorrhea in 3 successive periods	Premenstrual acne did not recur under B complex therapy
17 A 38	Profuse menorrhagia premenstrual tension and breast tenderness	3 yr	Lingual edema	Oral B complex	6 mo	Diminution in menstrual flow subsequent periods 5 4 3 3 3 3 days duration no premenstrual tension or breast tenderness	Premenstrual blepharocconjunctivitis since menarche at 12 except during pregnancy 3 yr before starting B therapy repeated subsidence of eye condition under sulfathiazole with invariable recurrence no recurrence following local sulfathiazole while on B complex
18 J H 33	Menometrorrhagia since menarche periods every 21 days duration 9-10 days	6 mo	Severe glossitis gingivitis recurrent vesicles oral mucous membrane	Oral B complex and additional niacinamide	3 mo	No intermenstrual bleeding after 3 wk of therapy 3 periods 7 6 and 5 days' duration interval increased to 27 days	Glossitis showed initial striking improvement but was still present 11 wk later other lesions cleared up completely

CASE REPORTS

Of 39 cases previously reported, 7 were presented in detail. Five of these 7 are still under observation. The pertinent data on all seven cases are recapitulated in Table I together with observations subsequently made. An additional 11 cases are presented in Table I in considerable detail. Owing to space restrictions, only 50 of the total of 54 cases are included in the tabulations of these 32 are presented more briefly in Table II. Four cases have been chosen for more extended exposition; they are numbered as in Table I.

CASE 8. A. O. aged 4 years, since her last pregnancy 6 years previously had had menorrhagia lasting from 10 to 15 days, this confined the patient to bed for the first 3 days of each period and required the use of as many as 4 large double pads per period. During the 6 years several curettages had been done, none of which had any effect on the menstrual flow. The last curettage was in September of 1934 the rodotestum showed cystic hyperplasia. This patient had an atrophic glomus. She received oral and, later, oral and parenteral vitamin B complex therapy. The first subsequent period after 1 month of therapy lasted 4 days, required 3 pads, the next 4 periods were of the same duration and required 1 pad for the first and 2 pads for the remaining 3 periods. Accompanying the improvement in the menstrual flow there was a striking improvement in physical well-being, as well as healing of the glomus. For 5 months subsequently this patient took vitamin B complex by mouth only (for the latter months more or less sporadically); the improvement in the amount and duration of the menstrual flow persisted until she stopped taking the B complex for 1 month on her own initiative. The menorrhagia recurred with her next period. On resumption of large oral dosage of B complex the subsequent period was normal.

CASE 9. R. F. aged 26 years, had had painful breasts and premenstrual tension for years. She had feared, trophic tongue, so sensitive she could not eat citrus fruits, acid cholests and many symptoms characteristic of B vitaminosis. Both breasts were firm, nodular and tender. Oral B complex therapy as instituted and there was moderate improvement in the breast tenderness and in the premenstrual tension over a period of 3 months, the glomus improved so that she could eat acid foods without irritation and the cholests disappeared. Previously susceptible to sunburn she now began to tan from solar irradiation for the first time in her recollection (this has been observed in several other patients on B complex therapy). The patient, as then on combined oral and parenteral therapy the breasts are no longer nodular and tender and there is no premenstrual tension, but even in the consecutive periods. After 1 month of combined oral and parenteral therapy there was loss of sores in the carpal crease of the hand and 1/4 inches in the hips, although the body weight remained stationary at 110 pounds. Clothing previously tight fitting was now loose.

CASE 10. M. W. age 34 1/2 years, had had menorrhagia since the menarche (the age of 13 years) she had

been bleeding continuously for 3 weeks when she was first referred for endocrine therapy. Rectal examination had revealed no abnormalities in the uterus or adnexa. A focal acne had been present since the menarche; this showed premenstrual exacerbations. For 4 months the patient had been on a greatly restricted diet for treatment of the acne, which had improved somewhat but was still present. She complained of constant nervousness and fatigue but was not aware of premenstrual tension. There was edema of the tongue, severe gingivitis, and ecchymosis about the nose. The thyroid was slightly and diffusely enlarged, the basal metabolic rate was plus 4 per cent. Oral B complex therapy as administered and the vaginal bleeding stopped in 3 days there was no further bleeding until exactly 25 days after therapy was begun, when period occurred which lasted 4 days. Abundant excessive flow. Unlike previous periods, the flow stopped abruptly without subsequent staining. The following 3 periods occurred at 3 day intervals and lasted 5, 5 and 4 1/2 days, respectively, all with normal flow. During the 4 months of therapy there was no intermenstrual bleeding, halitosis. The vitaminosis lesions and the subject's symptoms all cleared up promptly. There was great improvement in general well-being. Despite restoration to the diet of previously interdicted foods, the menstrual acne cleared up completely.

CASE 11. M. G. aged 34 years, had had premenstrual tension and recurrently painful, nodular breasts for 3 years before each period. Associated with these symptoms she had firm, tender mass in the upper outer quadrant of the right breast, which had been present for more than 10 years. It had been diagnosed as "cystic fibrosis" and she was advised against having it removed. At the time of examination it was disc-shaped, approximately 3 by 3 by 1 centimeter in dimensions. Until 6 months previously she had had severe menorrhagia, described by the patient as "deluge," but the flow had more recently become scant. The periods previously occurred every 9 or 10 to 17 days, more recently every 25 days and lasted 4 or 5 days. She had mild trophic glossitis and cholests (there were exacerbations of the cholests before the period) and ecchymosis about the nose. The patient complained of waking up feeling tired in the morning, sudden headaches, irritation and tearing of the eyes, rapid visual fatigue, numbness and pain in arms and legs, incurrent vessels in the oral mucous membrane, and tendency of the skin to bruise from slight contusions. She received oral and parenteral B complex therapy over a period of 3 months. There

was great improvement in the premenstrual tension and much less tenderness of the breasts; the mass in the right breast gradually diminished in size and after 3 months of therapy had completely disappeared. The vitaminosis lesions and symptoms all improved markedly. Among other changes, the skin bruised much less readily than before, and unlike the condition at the beginning of treatment, did not bleed from the puncture sites following the injections.

Including Cases 7, 31, 33 and 38, there were 14 cases in this series in which signs and symptoms of B complex vitaminosis were associated with benign myomas. All these patients had had menorrhagia, metrorrhagia or both and in 9 hysterectomy had been performed. Four had been on an extremely deficient diet for many years; in 2 cases the restricted diet had been imposed for the treatment of allergy; the other 2 the patient had an aversion to fruits and vegetables. One of the latter patients appeared for

Footnote for Table I

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treatment of unilateral cystic mastitis 8 months after the operation. Another patient who had had a supracervical hysterectomy, had bleeding from the cervical stump at two successive monthly intervals after the operation. A year later she came for treatment of cyclic tension and tenderness of the breasts for about 2 weeks of each month. In addition to the myomas, in 1 of these cases there was adenomyosis associated with large nabothian cysts in the cervical canal, in another there were cervical polyps.

Twelve patients with atrophic glossitis, cheilosis or both (and usually having other signs of B avitaminosis) were in the natural menopause when first seen, all 12 had a history of premenopausal menorrhagia.

ANALYSIS OF OBSERVATIONS

A number of the clinical implications of failure of the liver to inactivate estrogen in vitamin B complex deficiency while this organ continues to inactivate androgen, have been discussed in previous papers (5, 7, 8). Extension of the earlier clinical observations has raised several further points of considerable interest.

One important factor is that a number of patients who flowed usually for 5 or 6 days and had not considered this abnormal, subsequently flowed for not more than 3 or 4 days under B complex therapy. This indicates that it may be necessary to revise our concept of the normal range in the duration of the menstrual flow.

Characteristically, patients with only mild or moderate signs or symptoms of vitamin B deficiency, who had become accustomed to increased nervous tension, insomnia, tenderness of the breasts, a feeling of "fullness" or "puffiness," lumbar backache, headache, increased fatigability, lower abdominal cramps and the like, as premonitory indications of impending menstruation, reported after the first or second subsequent period while on B complex therapy, that the flow came on completely "without warning." Conversely, other patients, especially those who had signs of a more severe and more protracted deficiency and who were suffering from menorrhagia, reported that there had been dysmenorrhea for the first time while on vitamin B therapy, or that the pain had become more severe than before (this also occurred in one of the cases in which there were uterine myomas). In virtually every case in which this occurred there was little or no pain during subsequent periods while the nutritional therapy was continued.

Our observations in animals indicating that the estrogen-androgen equilibrium is altered in B

complex deficiency, is of especial interest in view of the response of the clinical conditions here discussed to treatment with androgens. We believe that the therapeutic effect observed with the androgens is due to re-establishment of the estrogen-androgen equilibrium at a higher absolute level. Administration of the B complex, in contrast, reduces the body estrogen to the normal range and thus re-establishes the equilibrium at a physiologic level.

The majority of the patients in this series had a low basal metabolic rate. This was especially true of the patients with signs of severe or moderately severe nutritional deficiency. Administration of thyroid to these patients, in the absence of a vitamin B supplement, usually caused exacerbation of the signs and symptoms of the deficiency without significant change in the metabolic rate. The low metabolic rate in these patients may be the expression of a safety mechanism, the rise in body estrogen resulting from failure of inactivation in the liver depresses the pituitary with diminution in secretion of the thyrotropic principle. An additional factor is the observation reported by Williams and Kendall that administered thyroid is "less effective in promoting metabolic activity" in a state of thiamin deficiency than it is when the intake of thiamin is adequate. This would explain the failure of response to thyroid observed in several of our patients and the improvement in this respect noted after adequate vitamin B complex therapy.

In 2 patients with enlarged thyroids a definite diminution in the size of this gland was observed after several months of therapy with vitamin B complex, this was sufficiently striking to be noticed spontaneously by members of their families. In neither of these cases, however, did the goiter completely regress during the period of observation. This is of interest in view of the well known observation that patients with goiters show periodic further enlargement of the gland during the latter part of the intermenstruum, when the body estrogen rises, and that administration of estrogen to some patients with hyperthyroidism leads to diminution in the basal metabolic rate (10).

Among other incidental changes observed in these patients, alteration in the skin and subcutaneous tissues were striking. A clearing and brightening of the complexion was usually one of the earliest changes observed on B complex therapy. This was noticeable in kodachrome photographs originally taken to illustrate the oral lesions and the changes under therapy. When first seen, in a number of the patients the skin was thin and hyperesthetic, large petechial hemor-

TABLE II.—GYNECOLOGIC AND ASSOCIATED DISORDERS OCCURRING IN PATIENTS WITH ATROPHIC GLOSSITIS OR CHEILOSIS OR BOTH AND WITH OR WITHOUT OTHER INDICATIONS OF DEFICIENCY IN FACTORS OF THE VITAMIN B COMPLEX

No. Patient Age	Gynecologic and associated disorders	Result of therapy with vitamin B complex
10 F 26	Premenstrual tension	Drinking improvement
10 M L	Premenstrual tension and breast tenderness	Subsidence of both conditions
1 S 47	Menorrhagia, periods 8-9 days' duration, premenstrual tension and breast tenderness	Menstrual flow diminished to 3-4 days during 8 mo. no premenstrual tension or breast tenderness
1 S 31	Menorrhagia, premenstrual tension, cervical polyp (permanently excised)	Gradual improvement
1 K 36	Severe premenstrual tension and breast tenderness, continuous apical discharge with premenstrual exacerbations	Drinking subsidence of all symptoms and diminution in duration of menstrual flow from 6-7 to 3-4 days
14 K 31 46	Prolong menstrual flow 6-7 days' duration for more than 3 yr. cystic mastitis and premenstrual tension	Marked relief of all symptoms over 1 mo. duration of periods 3-4 days
15 S 43	Uterine menorrhagia and amenorrhea for 3 yr. associated with an atrophic depression	Menstrual periods and days' duration, menstrual symptoms improved rapidly
16 J 26	Episodes of menorrhagia following pain in right of about 30 hr. from conception, increasing	Normal periods and days' duration without reduction of weight
17 F 30	Premenstrual tension, premenstrual chloasma and acne profuse menstrual flow	No premenstrual tension, no recurrence of chloasma or acne
18 K 33	Premenstrual tension, premenstrual over and (occasional?) chloasma	Subsidence of all symptoms in 1 mo.
19 F 30	Menorrhagia characterizing with amenorrhea	First normal period after menarche, days' duration
20 K 33	Menorrhagia, premenstrual tension and breast tenderness for 3 yr. endometrial polyp	Definite improvement in premenstrual symptoms and reduction in menstrual flow despite presence of polyp, later removed
1 C 3	Menorrhagia, premenstrual tension, unilateral cystic mastitis, small uterine fibroids	First normal period in 3 yr.; complete regression of nodules in breast, improvement in premenstrual tension
1 F 43	Menorrhagia, multiple uterine myomas	Considerable diminution in menstrual flow but local exacerbation of dysmenorrhea
1 K 33	History of menorrhagia associated with benign cervical polyp, later excised, premenstrual chloasma	Gradual subsidence of chloasma, moderate diminution of menstrual flow
1 S 33	Increase in duration of periods from 3-4 to 6-7 days post premenstrual tension and breast tenderness	Periods 4 days' duration no premenstrual tension, if still breast tenderness, exacerbation dysmenorrhea in period, no pain thereafter
1 F 34	Menorrhagia, 11 day interval, days' duration, premenstrual tension	Regular periods and days' duration interval 26 and 30 days, no premenstrual tension
10 S F 40	Prolong menstrual flow days' duration, premenstrual tension, premenstrual chloasma	Periods 4 days' duration, much reduced flow no premenstrual tension
17 F 34	Severe menorrhagia recurrent for 6 months periods 9-10 days' duration	Flow much reduced in 1 successive period, duration 3-4 days
18 F 33	Severe menorrhagia, endometriosis and cervical polyps (both removed)	Considerable diminution in amount and duration of bloodlet, despite presence of polyps and myomas. Apparent decrease in size of uterus by palpation about 30% in 1 mo. patient then asymptomatic

TABLE II—GYNECOLOGIC AND ASSOCIATED DISORDERS OCCURRING IN PATIENTS WITH ATROPHIC GLOSSITIS OR CHEILIOSIS OR BOTH AND WITH OR WITHOUT OTHER INDICATIONS OF DEFICIENCY IN FACTORS OF THE VITAMIN B COMPLEX—Continued

No. Patient	Case	Associated disorders	Treatment of the case with vitamin B complex
10 C.A. 16		Menorrhagia for 1 yr. on deficient diet	Normal period 4 days duration after 1 wk. on oral B complex
40 P.K. 47		Menorrhagia, long and irregular periods, nutritional deficiency and anemia since 1 yr. to 2 yr. duration	
41 L.S. 44		Menorrhagia, endometrial hyperplasia and dysplasia, premenstrual tension, restricted diet for 1 yr. to 2 yr. preceding excessive vaginal bleeding	
7 I.D. 19		Severe premenstrual tension and breast tenderness, profuse menstrual flow for 1 duration	
21 L.A.		Premenstrual tension	
44 H.D. 4		Premenstrual tension and breast tenderness, irregular case in duration of period from 1 to 4 days	
45 G.P. 41		Premenstrual tension and painful nodular breasts	
46 I.R. 40		Menorrhagia, period 14 days duration	
4 R.S. 14		Menorrhagia 1 yr. since menarche, periods last 10-12 days, extremely deficient diet	
48 R.M. 17		Extreme premenstrual tension and breast tenderness since pregnancy 12 yr. before	
40 A.M. 30		Premenstrual tension, chronic cystic mastitis, premenstrual stomatitis since pregnancy 5 yr. before	
50 S.S. 42		Menorrhagia, increase in duration from 5-6 to 13 days, premenstrual tension	

Cases 40 to 50 were not treated for a sufficient length of time; they are included to show the correlation between nutritional deficiency and the gynecologic disorders.

rhages occurred from slight contusions and bleeding was almost invariable from the needle tract when hypodermic injections were made. The subcutaneous tissue was flabby and the fat pads over hips and abdomen were well developed. Following oral and parenteral therapy with the B factors for from several weeks to several months, the skin and subcutaneous tissue became firmer, the skin was no longer hypersensitive, did not show "black and blue spots" from minor contusions and there was no longer bleeding following hypodermic injection. In addition, 3 of the patients (Cases 7, 11, and 13) noted, to our mutual surprise, that there was diminution in the deposition of fat about the hips, thighs and abdomen without the loss of any weight. In one of these patients this was confirmed by actual measurement. The anatomic fat pads mentioned are

specifically feminine attributes in the human being, and there is a great deal of evidence (derived both from spontaneous changes in body conformity in pathologic conditions and from the therapeutic use of estrogens and androgens) that the development of the characteristic female conformity is under the influence of estrogen. Thus, it is not surprising that, under favorable circumstances, reduction in the estrogen level (and alteration of the estrogen androgen equilibrium) might affect the deposition of fat in these areas. Hooker and Pfeiffer, in studies on the rat, have shown significant changes in the skin and subcutaneous tissues following treatment with estrogen or androgen.

Bean (1, 2) has reported the occurrence of cutaneous vascular spiders and palmar erythema in patients with nutritional deficiency and has

ated these changes to the effect of estrogen. Angiomas in the cutaneous blood vessels as a result of excess estrogen in nutritional deficiency and regression under treatment with B complex, could explain the diminished tendency to bleed, as we have observed.

In one of the cases reported here (Case 14) a mass in one breast that had been present for more than a decade, regressed under oral and parenteral complex therapy until it was no longer palpable. So long persistence of this mass makes it not unlikely that some fibroids were present, despite which complete (or virtually complete) regression occurred. In certain other cases, unpublished observations by one of us (G. R. B.) indicate that,

cystic mastitis with palpable masses of long duration, lesions that are presumably fibrotic have shown little or no significant diminution in size with oral and parenteral B complex therapy, even though pain and tenderness were well controlled. Breast nodules of shorter duration, which could be largely or predominantly epithelial in structure, and especially those which develop only during the latter part of the intermenstruum, regress rapidly and usually completely and do not recur under vitamin B complex therapy. Some of these masses that have persisted for months or years may show partial regression; this is probably due to diminution in size of the epithelial elements, leaving smaller palpable nodules of fibrous tissue. Whether or not the connective tissue elements of these lesions can be affected by reduction in the estrogen level through enhanced inactivation in the liver remains to be decided by further study.

Studies on the endometrium of the cases with pathologic uterine bleeding are still under way, but certain preliminary observations may be mentioned. It is of course well known that bleeding may occur from endometrium of various types among those observed by us in cases reported here; there have been mucous showing cystic hyperplasia and others in the early proliferative phase. All the patients having excessive bleeding from endometrium of these types showed striking improvement under vitamin B complex therapy. However, in an unpublished case of Novak hyperplasia of the endometrium observed by one of us (G. R. B.) there was no significant diminution of bleeding under B complex therapy and little change in the histologic picture.

Of the patients with nutritional deficiency who were in the menopause when first seen, most were relieved of their flushes by administration of estrogen but continued to have a multiplicity of complaints such as headaches, nervousness, light-headedness, insomnia, numbness and pain in the

upper and lower extremities and the like. In several cases the estrogen was withdrawn and vitamin B complex was substituted. The avitaminotic lesions healed and the associated symptoms subsided. Even though the patients continued to have flushes they did not find them sufficiently disturbing to demand further estrogen therapy. It seems likely that many of the symptoms often associated with the menopause are really due to nutritional deficiency. And because the body estrogen is excessively high in B complex vitaminosis the vasomotor instability considered characteristic of the menopause may be made more severe by a rapid decrease in the body estrogen from this excessively high level. It may be that in the absence of nutritional deficiency with its associated failure of inactivation of estrogen in the liver, the total decrease in the estrogen would not be so great and the vasomotor symptoms correspondingly not as severe. The menopause may then be a physiologic phenomenon which does not require endocrine therapy.

The oral vitamin B complex preparations used in this study were usually given after meals in doses providing per day up to 9 milligrams and occasionally as much as 24 milligrams of thiamin, 9 milligrams or more of riboflavin and from 60 to 10 milligrams of niacin amide together with other factors of the vitamin B complex derived from rice bran, yeast, liver or all three. Patients with mild or moderate vitamin B complex deficiency usually respond well to any of these products; those with a more severe avitaminosis seem to respond better to the preparations containing extracts of liver. Parenteral administration provided an additional 40 or 50 milligrams of thiamin, from 5 to 5.5 milligrams of riboflavin, from 5 to 8 milligrams each of pyridoxine and calcium pantothenate and from 40 to 50 milligrams of niacin amide every second or third day. It has been our experience that parenteral administration of the B factors, especially when large doses of thiamin are included, is best made during the daytime. If given within 3 or 4 hours of bedtime a restless night may ensue.

The necessary duration of oral and parenteral therapy with the vitamin B factors in cases of the types described cannot yet be decided. A few patients that received parenteral therapy over a period of several months were subsequently maintained successfully on moderate dosage of the B complex orally. Others have regressed promptly soon as the oral dosage was reduced or the parenteral therapy discontinued. Since there are at present no adequate methods of determining precisely the nature, the degree or the reversibility of

the deficiency in a given case, the type, amount, and duration of therapy must be adjusted to the individual response. In perhaps the majority, and possibly in all the cases, large doses of the entire B complex must be administered indefinitely, especially as the average patient fails to correct the nutritional inadequacies of the usual American diet, or, having been persuaded for a time to correct it, will soon revert to one that is grossly deficient in the protective factors. And in several cases under treatment for nutritional deficiency for periods as long as 4 years, it has not been possible, after the vitamin reserves of the body had presumably been restored by intensive oral and parenteral therapy, to prevent recurrence of the lesions by diet alone. It has repeatedly been pointed out by many workers, but it will bear emphasis at least once again, that the infinitesimal dosages often employed, such as 1 or 2 yeast tablets 3 times a day, have little effect in the treatment of B complex avitaminosis. Reference is made to an excellent recent summary by Spies of the principles concerned in nutritional therapy.

SUMMARY

Observations in 104 patients provide further evidence, in extension of that previously reported, that menorrhagia, metrorrhagia, cystic mastitis, premenstrual tension, and probably uterine myomas as well, are caused by failure of the liver to inactivate estrogen owing to deficiency of factors of the vitamin B complex. Of 39 patients who were observed primarily because of the presence

of lesions of nutritional deficiency, 37 had a history of one or more conditions related to excess estrogen. Of 52 patients whose main complaint was one of the latter conditions, and who were examined for evidences of nutritional deficiency, every one had signs or symptoms or both characteristic of B avitaminosis. Prompt and often dramatic responses were obtained in the gynecologic conditions with vitamin B complex orally, parenterally, or by both routes. Incidental changes are reported in the skin and subcutaneous tissues and in the deposition of body fat. Changes in the size and function of the thyroid are discussed.

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A NEW TECHNIQUE FOR USING THE LEVINE TUBE IN BILIARY INTESTINAL ANASTOMOSES

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COMPLETE obstruction of the bile ducts, whether from congenital atresia (5) strictures, inflammatory processes, or neoplasms always presents a serious problem. Unless the biliary atresia is effectively relieved the outcome is invariably fatal. The primary aim therefore, of any reconstructive operation is to provide adequate communication between the unobstructed segments of the biliary tree and the gastrointestinal tract. Much has been written concerning the relative merits of uniting the gall bladder or its bile ducts to the stomach, duodenum, and jejunum. Each operation has its merits and its disadvantages. As a rule however the operator is compelled to accept the simplest and most expedient measure of relieving the dangerous obstructions, for these patients are poor surgical risks.

GENERAL CONSIDERATIONS

In our experience there have been four fundamental complications which have proved most annoying namely leakage at the site of anastomosis, failure to relieve the obstruction, stenosis of the new ostium and a latent cholangitis. An appreciation of the pathogenesis of these tantalizing complications affords the only solution to their prevention.

It is most difficult to obtain a watertight union between the distended gall bladder and the bowel because of the marked disproportion in the thickness of their respective walls. If the approximating sutures are drawn together too tightly they may cut through the thin wall of the gall bladder and liberate the septic bile. On the other hand, hyperperistalsis and gaseous distention may produce undue tension on the sutures causing them to cut through the gastrointestinal wall thereby producing an in-

ternal fistula with its lethal peritonitis. Walters has warned against the dangers of undue tension on the sutures being responsible for the majority of anastomotic leakages. On several occasions we have been chagrined to see what was thought to be a perfect anatomical anastomosis become separated. Apparently the distended gall bladder which had permitted a satisfactory union, subsequently contracted as its intravesical pressure was reduced thus initiating constant tension which caused the sutures to pull out.

Failure to relieve the biliary obstruction by reconstructive operations occurs much more frequently than is appreciated. Best and Hicken have demonstrated that cholecystoenterostomies may fail to relieve an obstructive jaundice simply because the cystic duct has been occluded by an unrecognized calculus or kink. They affirm that the presence of bile in the gall bladder affords no assurance that the cystic duct will continue to provide adequate drainage of the obstructed choledochus, for as soon as the distended gall bladder has been evacuated the cystic duct may shrink sufficiently to close this conduit for the escape of the bile. Occasionally the plastic operation will so stretch or distort the gall bladder that it angulates or kinks an otherwise patent duct hence the operation becomes futile. On one occasion a postoperative hemorrhage into the transplanted gall bladder occluded the cystic duct thus negating the benefits of cholecystoduodenostomy. Again an unrecognized stone in the common hepatic duct accounted for the failure of a cholecystogastrostomy. It is apparent that the operator has many facts to consider in selecting the proper corrective procedure.

Cicatricial closure of the anastomotic opening is a latent but troublesome complication. Ladd and Gross believe that this will not occur

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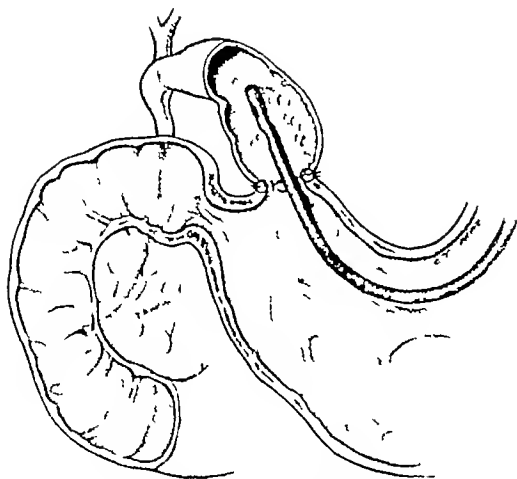


Fig 1 A cholecystogastrostomy with the indwelling Levine tube. Note the retaining suture, which prevents the catheter from slipping back into the stomach.

if care has been taken to unite the mucosal surfaces of the two component structures. The mucosa-lined stoma inhibits the chemical irritation of the deeper muscular layers, thus minimizing scar formation. Walters emphasizes the necessity of making the orifice large enough to compensate for the inevitable postoperative edema around the line of suture. If this is not done, the walls of a small stoma may become contiguous and adhere to each other. McArthur devised a special indwelling rubber tube which he placed in the anastomotic opening to keep the newly formed estuary open until the edematous phase has subsided. Occasionally these tubes failed to pass on into the gastrointestinal tract and, becoming plugged with the detritus from the biliary tree, they effectively occluded the new orifice.

Latent cholangitis and suppurative hepatitis may complicate any and all types of biliary anastomoses. Ascending infection combined with the chemical irritation from the reflux of pancreatic and gastrointestinal secretions quite naturally invite such disasters. (2) Zollinger devised the tubular gastric stoma in hopes of overcoming this difficulty. Lahey suggested that the reflux phenomenon was less when the bile was emptied into the jejunum than when other segments of the gastrointestinal tract were selected for the reconstructive operation.

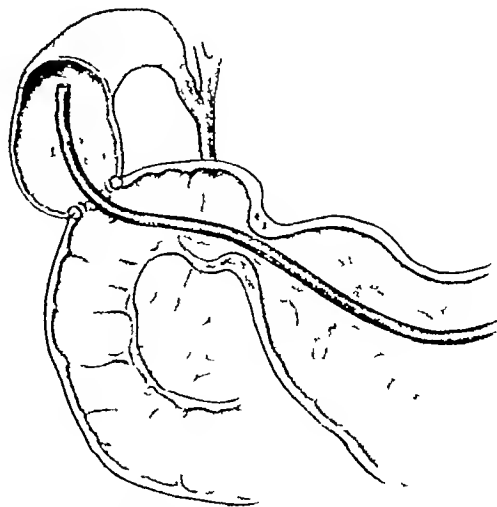


Fig 2 A cholecystoduodenostomy. The Levine tube has been coaxed through the pyloric ring. Retaining suture is illustrated in this drawing also.

Ladd and Gross, however, believe that these complications are not so dangerous as some authors contend, for they report several cases in which patients were apparently well 16 years following cholecystogastrostomies. These operations are never elective and all hazards must be assumed if an attempt is to be made to relieve the complete biliary stasis.

TECHNICAL CONSIDERATIONS

The selection of the type of biliary intestinal anastomosis to be employed is determined by the site of the obstruction, the patency of the ducts, and the versatility of the surgeon. The simplest and most expedient method of relieving the occlusion should be utilized. Experience has proved that certain principles must be followed if a satisfactorily functioning stoma is to be obtained.

1 The size of the artificial stoma must be adequate to permit the free drainage of bile and not large enough to invite the regurgitation of intestinal juices into the biliary tract. If the gall bladder and bile ducts are dilated, one must allow for the inevitable shrinkage which occurs when these structures regain their normal tonus. This "contracting phenomenon" apparently accounts for many "nonfunctioning stomas," particularly if the choledochus or common hepatic bile ducts are utilized. Like-



Fig. 3. A cholangiogram made on the operating table to test the patency of the cystic duct. This, as performed before the reconstructive operation, as done. Observe the enormously dilated common bile duct, which is so completely excluded that none of the duodenal escapes into the duodenum. Gall bladder; dilated common bile duct; patent cystic duct.



Fig. 4. A postmortem cholangiogram made by introducing the contrast media through the cholecystogastrostomy stoma. Note the enormously dilated common bile duct which drains through the patent cystic duct into the gall bladder and through the gastropholecystic stoma into the stomach. This patient died of pulmonary embolism on the 3d postoperative day.

wise it is much easier for any postoperative edema to close the stoma if it should happen to be too small.

2. *Extreme care must be exercised to render the anastomoses watertight (2).* This can be accomplished by the use of the same technique as is employed in performing a gastroenterostomy. The inner layer of sutures securely unites the mucosal linings of the two component organs while the outer or reinforcing layer firmly approximates the muscular and serosal tissues. Several retaining sutures are placed above and below the stoma to absorb any tension which might be exerted from distention or motion of the gastrointestinal tract. Whenever possible some fatty tissues from the omentum, the gastrophobic and the duodenohepatic ligaments are securely anchored around the fusion line to minimize the dangers of leakage.

3. During the past 3 years we have employed a new technique which insures the functional integrity of the anastomoses. It has been employed satisfactorily for cholecystogastroenterostomies, choledochogastroenterostomies, and

hepaticogastroenterostomies. The ease of execution and the immediate relief of the biliary obstruction certainly recommend its use.

The technique is as follows: During the preoperative period the stomach is repeatedly lavaged thus removing accumulated fluids and residue. Just before the operation is begun a previously sterilized Levine tube is passed into the stomach. When the new openings have been made let us say between the stomach and the gall bladder, the tip of the catheter is pulled through the gastric incision and inserted into the lumen of the gall bladder so that 2 inches of the tube lies within the gall bladder cavity. The tube is then securely anchored to the gastric mucosa and muscularis by fine No. 000000 chromic catgut sutures (Fig. 1). This prevents the catheter from slipping back into the stomach. When a choledochogastroenterostomy is performed the Levine tube is coaxed through the pyloric ring and then introduced into the common bile duct (Fig. 2). A similar procedure has been followed when working on the hepatic ducts or the jejunum. It has been most pleasing to observe the ease with which



Fig 5 An operative cholangiogram made by introducing diodrast into the Levine tube. Note that the contrast media traverses all of the duct system and escapes through the newly formed stoma into the stomach and duodenum 1, Gall bladder, 2, Levine tube, 3, escaping media into the stomach, 4, dilated common bile duct, 5, diodrast in the duodenum



Fig 6 Same patient 10 days later The delayed cholangiogram demonstrates an effectively functioning cholecystogastric stone Note that there has been no leakage of the contrast media into the peritoneal cavity

the anastomoses can be made around the indwelling catheter.

The use of the Levine tube has the added advantage of permitting the visualizing cholangiographic studies to be made while the patient is on the operating table (3). As soon as the anastomosis has been completed, and before the abdomen is closed, an assistant introduces 20 to 50 cubic centimeters of sterile diodrast into the external orifice of the Levine tube and an immediate x ray picture is taken. If the contrast media traverses and fills all of the biliary radicals one is safe in assuming that the ducts are patent and that the bile can follow the same channels and escape into the gastrointestinal tract. Any obstructive lesion produces a recognizable deformity and corrective steps can be promptly employed. If the suture line is impervious to the diodrast there will be no leakage of bile. Should one detect a slight seepage of the contrast media at any given point of the anastomotic line this defect can be corrected before the peritoneum is closed.

Even under ideal conditions both choledochointerostomies and hepaticointerostomies present many technical difficulties. The small caliber of the ducts and the deep cavities in which one must work merely add to the hand icaps. When the Levine tube is used however it forms an excellent pattern around which the new stoma can be made. If the selected catheter has the same diameter as the bile ducts then adequate drainage is obtained and any seepage prevented. The semiflexible catheter provides a firm support for the stoma thereby preventing postoperative occlusion from edema, kinking or contact fusions. By the time the catheter is ready to be removed there will be a firm cicatricial reinforcement around the anastomosis.

The postoperative courses of all our patients have been most pleasing. The immediate relief of the complete biliary obstruction causes the jaundice to subside, the liver regains its functions, and improvement is most rapid. By means of a continuous suction to the external end of the Levine tube the thick, acid bile can be effectively aspirated thereby lessening the hydrostatic tension on the suture line. If the diseased biliary tract should contain thick

mucus, biliary sand, blood clots or pus, undesirable material can be removed by aspirating lavages, hence insuring adequate drainage.

Routine postoperative cholangiograms made on the 7th to 10th postoperative day. If the bile ducts have regained their normal size and tone and if the bile has no abnormal appearance, then the Levine tube can be removed with impunity. The ability to remove the indwelling catheter overcomes the objections which result from the use of the Mc. Thur tube. No residual rubber tubing is left in the stoma to become incrustated and obstructed. As soon as the Levine tube has been removed the bile flows into that segment of the intestinal tract where it can best aid in the digestion and assimilation of food. This does away with the annoying and distasteful dressings which necessarily accompany all forms of external fistulas.

REPRESENTATIVE CASES

CASE 1. F. male, aged 76 years, had complaints of progressive painless jaundice for 6 weeks. Anorexia, nausea, vomiting, weakness and loss of pounds of weight were his main concerns. Physical examination disclosed a small, firm, fixed mass in the epigastrium. His arterial blood as 55 prothrombin time as seconds. Roentgenograms were negative for cholelithiasis or malignant invasion of the biliary system.

When the abdomen was opened, large tense, non-calculous gall bladder was found. No stones were present. The dilated common bile duct measured 1.5 centimeters in diameter. The pancreas was about its normal size and had encircled the choledochus in such a manner as to produce compression and occlusion of the ampulla of Vater. Biopsy demonstrated an adenocarcinoma of the pancreas.

The extensive pancreatic involvement precluded any possibility of resecting the malignant tissue to allow choledochogastrostomy as performed. The Levine tube which had previously been passed into the stomach, as coated through the choledochogastrostomy stoma, so that its tip lay well within the gall bladder cavity (Fig. 1). In order to test the patency of the cystic and common hepatic bile ducts, the Levine tube was injected with 45 cubic centimeters of diodrast and an x-ray picture was taken. The resulting cholangiogram revealed that the contrast media had passed from the gall bladder into all of the biliary radicals, hence these patent ducts afforded an adequate drainage channel by which the toxic bile could escape into the stomach (Fig. 2). As soon as patient

was returned to his room, continuous negative suction as applied to the indwelling Levine tube and during the first 7 hours 55 cubic centimeters of bloody, viscous bile was aspirated. He died on the 72d postoperative hour from massive pulmonary embolism.

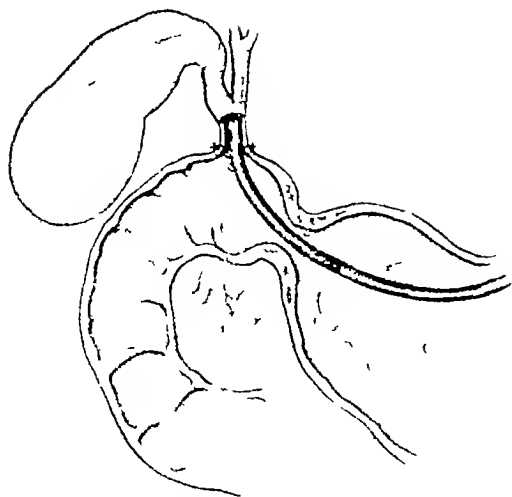


Fig 7 A drawing of a cholecystoduodenostomy for fibrosing pancreatitis. Note the Levine tube passing through the newly formed stoma into the obstructed common bile duct.

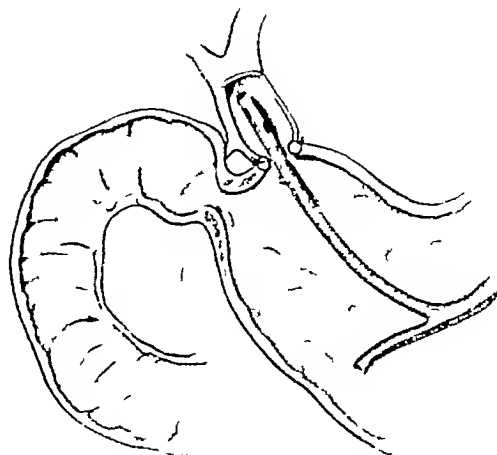


Fig 8 Hepaticoduodenostomy. Note the double lumen decompression tube which keeps the stomach and hepatic ducts decompressed. The common bile duct is a collapsed fibrotic strand of tissue.

The postmortem picture was described by Dr John H. Carlquist as follows: "The anastomosis appears to be firm, secure, and presents no evidence of bile seepage. The mucosa of the gall bladder and stomach had fused in a very smooth manner and the bile ducts were completely decompressed (Fig 4). The tip of the Levine tube extended well into the lumen of the gall bladder and had effectively relieved the gall bladder and bile ducts of their contents. There was no evidence of inflammation or pressure necrosis at the point where the tube passed through the newly made stoma."

CASE 2 A farmer, aged 60 years, had been troubled with an "itching jaundice" for 3 weeks. He gave no history of an antecedent biliary colic or in digestion. Progressive weakness characterized by a loss of 34 pounds of weight were his presenting complaints. The icteric index was 95, prothrombin time, 23 seconds, blood urea nitrogen, 48 milligrams per 100 cubic centimeters of blood, and the urine contained urobilin.

When the abdomen was opened a greenish black liver was found to extend 2 inches below the costal margin. The thin walled gall bladder was about four times normal size and contained 175 cubic centimeters of viscid black bile. The choledochus measured 2½ centimeters in diameter. The head of the pancreas was enlarged, firm, and nodular, and had completely surrounded the common bile duct, thereby compressing its lumen. No stones were present. As the dilated gall bladder and the stomach were contiguous, the two were anastomosed together, thus providing an escape into the gastrointestinal tract for the stagnant bile (Fig 5). The Levine tube was pulled into the stomach and drawn through the newly formed stoma, so that it lay within the lumen

of the gall bladder. It was anchored to the stomach wall by No. 80 cotton suture, so as to prevent its slipping back into the gastric cavity. By the injection of diodrast into the Levine tube, the contrast media made visible the cystic duct, thus showing it to be patent (Fig 6).

Postoperative course was most pleasing. On the 5th postoperative day the jaundice had disappeared as evidenced by an icteric index of 18. A delayed cholangiogram was made on the 10th postoperative day—the common hepatic duct and the finer biliary radicals were no longer dilated and the contrast media flowed through the stoma into the stomach. During all this period there was no leakage of bile from the abdominal incision. Two days later the Levine tube was removed. He was discharged on the 18th postoperative day. It is now 6 months since operation and he has gained 24 pounds in weight and is working every day. The pancreatic tumor had increased in size but there has been no recurrent jaundice.

CASE 3 R.S., housewife, aged 56 years, had had recurrent attacks of "gall stone colic" during the past decade. Five years ago her gall bladder "which contained many small stones" was removed. While convalescing from the operation she suffered three attacks of "gall colic." Three years ago she had a protracted siege of colic associated with jaundice. Since that time she has been jaundiced on four different occasions, the last episode being 1 week prior to admission. Icteric index was 85, blood urea nitrogen was 42 milligrams per 100 cubic centimeters blood, prothrombin time was 35 seconds, and the urinary urobilin was 3 plus.

No difficulty was experienced in exposing the common bile duct. The supraduodenal segment meas-

TABLE I—RESULTS

Patient	Disease	Operation	Days tube removed	Result
M 76	Cancer pancreas	Cholecystogastrostomy		Died 1st. Pulmonary embolism
M 60	Cancer pancreas	Cholecystogastrostomy	2th	Living 3 months later. No jaundice
F	Cancer pancreas	Cholecystogastrostomy	2th	Died 2 months. No jaundice
M 64	Cancer pancreas	Cholecystogastrostomy		Died 2th day after operation. Hepatic death
M 76	Cancer pancreas	Cholecystogastrostomy	2th	Well 2 months. No jaundice
M 66	Cancer pancreas	Cholecystogastrostomy	2th	Died 2 months. Carcinomatous
I 76	Chronic pancreatitis, common bile duct stricture	Cholecystogastrostomy	2th	Well 2 months
F 46	Stricture common bile duct	Hepaticogastrostomy	2th	Well 2 months
F 76	Pancreatic stricture common bile duct	Removal stomach. Cholecystogastrostomy	2th	Well 2 months
I 76	Stricture common bile duct	Cholecystogastrostomy	2th	Well 2 months
F 76	Stricture ampulla of Vater	Cholecystogastrostomy	2th	Well 2 months

red 3 centimeters in diameter. The enlarged succulent pancreas completely invested the ampulla of Vater and precluded any possibility of palpating choledochal tone. In an attempt to expose the retrocolic portion of the choledochus by mobilizing the duodenum rather brisk hemorrhage was encountered. The choledochus was opened but its lower segment seemed obstructed either with stone or inflammatory tissue. The annoying hemorrhage prevented further exploration. In order to relieve the intense biliary tension choledochal odenostomy was performed (Fig 7). The Levine tube was pulled from the stomach into the duodenum and its tip threaded up into the common hepatic duct. The anastomosis was reinforced around the tube and the abdomen was closed.

The Levine tube as attached to decompression bottle and 860 cubic centimeters of bile was recovered during the first 24 hours. Patient made rapid recovery. On the 9th postoperative day the aspirated material contained duodenal content indicating that the tube had slipped out of the common hepatic duct into the duodenum. Apparently the No. 00000 chromic catgut suture which had been used to anchor the Levine tube had been absorbed. By this time her icteric index was but 20 and the stools had normal brown color. Hence the Levine catheter was removed. She was discharged on her 8th postoperative day and has remained well during the past two years.

CASE 4. Hepaticoduodenostomy. A. J. housewife, 46 years old, had had her gall bladder removed 6 months previously. She did very well until 6 months ago when she began to complain of anorexia, nausea, and continuous jaundice. The icteric index was 75, prothrombin time 48 seconds, and the urine contained bile and urobilin.

A laparotomy disclosed an enlarged, congested, and deeply pigmented liver. The common hepatic bile duct was as large as one's thumb and seemed to end in a small fibrotic strand at the point where it

joined the choledochus. In spite of meticulous exploration we failed to identify the common bile duct, even after exploring the retrocolic area. As the stomach lay against the dilated common hepatic duct the two were anastomosed. A No. 6 Levine tube, which had been previously passed into the stomach, was threaded through the new stoma and its tip was inserted into the hepatic duct. The main portion of the tube was securely anchored to the stomach wall with No. 00000 chromic sutures (Fig 8).

During the first 48 hours 565 cubic centimeters of thick greenish bile was recovered from the Levine tube by means of continuous suction. The jaundice rapidly subsided, for on the 6th postoperative day the stool had normal color. A delayed cholangiogram was made on the 16th day which revealed the stoma to be working, for the diatrizoate, which was injected into the common hepatic duct, rapidly escaped into the stomach. The Levine tube was removed on the 21st postoperative day and the patient is now well 38 months after her operation.

RESULTS

To date we have employed the principle of the indwelling Levine tube for decompressing an obstructed biliary tree in 11 cases. Six of these patients had such an extensive adenocarcinoma of the pancreas that resection or excision of the malignant tissue was impossible. Our aim has been to relieve the biliary obstruction thereby correcting the tantalizing itching which invariably complicates the intense jaundice. Table I reveals that there were but two operative deaths, one from a massive pulmonary embolism, and the other from hepatic insufficiency.

Experience dictates that in dealing with cancer of the pancreas, choledochenterostomies are more effective in relieving the biliary stasis than is a cholecystenterostomy. In two instances autopsies have revealed that the enlarging pancreatic tumor may produce so much tension and distortion of the gall bladder that it causes either a kinking or tension occlusion of the cystic duct, thereby reproducing the biliary obstruction. In each of these cases the common duct was still dilated and had it been anastomosed to the stomach or duodenum such unfortunate complications would have been obviated.

CONCLUSIONS

A new technique for biliary intestinal anastomosis is described, the essential feature being the use of an indwelling Levine tube for continuous decompression of the obstructed bile ducts. The Levine tube, which has been passed into the stomach just before beginning the operation is pulled through the newly formed stoma so the tip of the catheter lies well within the lumen of the obstructed segment of the biliary tree. A watertight anasto-

mosis is made around this catheter. Continuous suction keeps the bile ducts completely decompressed and hence causes no malfunctioning internal biliary fistula. Choledochenterostomies, choledochocystostomies and hepaticocystostomies have all been performed by this technique. The excellent results which have been obtained, combined with the simplicity of the procedure strongly recommends its use.

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CARE OF THE INJURED IN COMBAT ZONES

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ALTHOUGH not much data are available from our own medical officers in foreign theaters of war upon which to base the teaching of first aid and early hospital care of battle casualties. Thus in training our medical officers and men who are to serve in units overseas we must rely on such modifications of the methods of World War I made necessary by changed conditions of warfare as have come to us from other sources.

The reports from the British have been very helpful. As an example Colonel Gillespie British Army Medical Services Liaison Officer on duty at Carlisle Barracks, has distributed some highly informative notes on battle casualties in the Middle East as a result of the fighting in September, October and November 1942. These valuable first hand facts proved in the actual crucible of combat experience have been most illuminating and have been borrowed from freely.

Nearly a year ago the War Department issued *Training Manual No. 8-210* entitled *Guide to Therapy for Medical Officers*. This booklet was compiled largely from recommendations of the subcommittee of the Division of Medical Sciences of the National Research Council and is excellent because of its clarity, conciseness, and its emphasis on essentials.

The Surgeon General issues from time to time circular letters regarding various subjects. These letters represent in concise form a directive or a bulletin, and have been found to be a decidedly useful way of distributing new factual material.

Finally there are appearing in British and American surgical journals, both civilian and military, a stream of articles on war surgery that contain valuable contributions to our fund of knowledge of this important field.

Much of what is to be considered here may seem elementary or commonplace. It is how-

ever of importance and for this reason it is presented without further apologies.

PRINCIPLES OF FIRST AID IN TREATMENT OF SHOCK AND HEMORRHAGE

Primary objectives are to save life, to relieve pain, to arrest hemorrhage and to combat shock. of urgent need also are the prevention of avoidable contamination by protection of the wound against additional soiling and the alleviation of discomfort and apprehension.

Most severe accidents, injuries, or wounds are associated with some degree of shock. In burn cases this is especially true. The importance of immediate therapy is such that it should take precedence over all other except the arrest of profuse hemorrhage and the relief of mechanical obstruction to respiration.

Shock is a state characterized by profound alterations in the physiology of the circulatory and respiratory systems. There is a lowered blood pressure, rapid heart action with weak pulse and shallow rapid respiration; there is pallor, weakness, and often subnormal temperature. The recognition of a state of shock is most important. The medical officer should at least suspect it on sight and proceed at once to confirm his suspicions.

While everyone is no doubt familiar with the types of injuries that are usually associated with shock, it should be pointed out that the nature of modern warfare is peculiarly constituted to provide the shocking type of trauma: these include blast injuries, crushing due to mechanized equipment. Burns are frequent in land as well as naval action since much of the fire power is mechanized and explosions and fires are productive of many serious burns.

Punctured wounds due to machine and automatic rifle fire as well as to shrapnel and hand grenades are similar to those seen in the last war.

Treatment of shock The ideal treatment of shock is preventive and the change in the pro-

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ture is a real triumph of modern surgery. Preventive measures are (1) gentleness in handling and transporting injured persons especially in cases of major fracture, (2) prevention and control of hemorrhage, (3) prevention of or correction of dehydration, (4) prevention of loss of body heat placing of wounded in (5) Trendelenburg position. Active measures include (1) relief of pain by administration of morphine in adequate doses—at least $\frac{1}{2}$ grain for a severely burned adult, (2) the use of plasma in adequate doses—burn cases need large amounts, the hematocrit reading is a useful guide as to quantity required, (3) avoidance of any disturbance and particularly any surgical procedure or even extensive examination while shock is being successfully combatted. If operation is imperative, shock may be combatted by one team while another proceeds with the operation, such cases are desperate and are the exception.

When a casualty arrives at a dressing station the following steps are in order (1) Look at the tag and see what has been done already and read any notes that may appear thereon, (2) transfer patient from stretcher to warmed bed, (3) remove clothing with minimum fuss, shears being used if necessary to avoid further disturbance, (4) note general condition, (5) examine for hemorrhage, either external or internal, crushing injuries, nerve injuries, (6) record pulse, respiration, and blood pressure every 15 minutes, (7) cover with blanket, permit rest and quiet, (8) observe patient frequently, (9) if patient is pulseless when first seen or is obviously in grave shock, leave him on stretcher. Don't undress him but administer plasma before anything else is done.

Resuscitation wards The resuscitation ward in desert warfare as developed by the British has played a very important rôle in surgery of the combat zone. The most serious cases are sent here and upon the efficiency of resuscitation and upon the selection of the optimum moment for operation, the life of these wounded may depend. The work of the field transfusion units is highly praised in accounts from the Middle East.

However, a word of caution is sounded so effective is their work that it is felt that

resuscitation may become an end in itself and not be regarded in the light of the clinical picture. In spite of transfusion, shock continues one should consider that a continuing cause may exist such as active bleeding, peritonitis, anaerobic infection, or absorption from mangled useless limbs, if one of these is responsible further transfusion is as useless as pumping a punctured tire. Thus, it is important that frequent regular inspection of patients in this ward be made by a surgeon who can reassess the cases with the resuscitation officer. Once the "one best time" for operating on a patient is gone it will never return.

Human albumin is now being procured in such form as to make its use intravenously relatively satisfactory as a blood derivative for the treatment of shock and burns. It has great advantages where space is a problem. It should be pointed out that its use in patients in whom a concealed hemorrhage is a possibility is not without risk of complications, its ability to produce a rapid rise in blood pressure may cause bleeding from wounds closed while the pressure is low and large hematomas may follow. If the neck is involved pressure symptoms might be serious. Similarly great caution should be used in administering the drug in casualties with stab or gunshot wounds of chest or abdomen until large bleeders have been ligated. It is probable, however, that for warfare where space is at a premium the use of albumin will be expanded. The maximum amount of albumin which should be administered to any one patient is probably 250 grams. The initial dosage is one unit, i.e. 100 cubic centimeters of a 25 per cent solution, roughly equivalent to 500 cubic centimeters of citrated plasma.

The British in the Middle East consider blood definitely superior to plasma for men who have suffered severe hemorrhage. It fits them for operation more rapidly and its effect is more sustained. However, plasma is still supplied to forward units since there blood cannot be kept in condition.

After shock and hemorrhage are disposed of the simplest emergency first aid involves (1) removal of foreign bodies, (2) implantation of a sulfonamide in the wound to arrest bacterial activity, (3) application of large sterile

dressing bandaged with moderate pressure (4) immobilization of the injured part splints being used when indicated.

These steps can be carried out as actual first aid measures before the patient is transported back to a hospital where formal débridement or other definitive treatment can be carried out. It is probable that the introduction of sulfonamides into a wound as an immediate first aid measure has made it possible to debride successfully after a longer lapse of time than if no sulfa drug had been implanted at the time of the injury. When there is considerable delay in transporting the injured soldier back to the hospital this is a matter of importance.

TREATMENT OF WOUNDS OF SOFT PARTS

In civil life flesh wounds are often seen within 1 or 2 hours after injury. Also the nature of the wound makes débridement and primary suture frequently acceptable in these cases. That conditions are much less favorable in war wounds has long been appreciated. However it appears that the warning must again be emphasized that as expressed in a note from a Middle East surgeon "War Surgeons should know that primary suture in forward units is unsuccessful and may be disastrous some wounds were sutured and arrived septic. Thus, it seems clear that in wounds received in combat areas, primary suture after débridement is not to be recommended. The principles of treatment are the same everywhere, namely (1) control of hemorrhage (2) removal of contaminating organisms (3) removal of damaged or devitalized tissue (4) prevention of further injury and further contamination with bacteria. The steps in the treatment of a wound of the soft parts briefly are the following

- 1 Under an anesthetic and if indicated a tourniquet to control bleeding the damaged tissue is removed major bleeders are ligated and the wound is protected from further contamination by a sterile compress or pad.

- 2 As soon as possible preparation for débridement is carried out by washing the skin adjacent to the wound with a nonirritating neutral soap and water with cotton sponges benzene is useful to remove grease or dirt

followed by sponges soaked in 70 per cent alcohol until the area is thoroughly cleaned.

- 3 Débridement is done under strict asepsis. This implies operating room technique including masking of the nose and mouth. A narrow rim of damaged skin is excised. Devitalized tissue blood clots, and foreign material are removed by means of clean sharp dissection. A fresh set of instruments is used for the dissection of the depths of the wound. Meticulous hemostasis is accomplished with fine suture material (catgut silk, or cotton). After débridement the wound should be irrigated carefully and extensively with sterile normal saline solution until all minute particles of blood, tissue and debris have been flushed away the wound is then lightly dusted with sulfanilamide powder and packed lightly with sterile gauze or with a plain vaseline gauze. The outer dressings should encircle the wound—sterile sheet wadding is useful for this purpose. In wounds of the extremities the tips of the fingers or toes should be left exposed for observation of the circulation. In the Egyptian campaign some wounded were transported with dressings that were loose on arrival so that wounds became exposed a dressing applied forward has to stand the test of many hours of transport of transfer from stretcher to bunk and vice versa, and in many cases of a restless patient. Strapping over the dressing itself and a firm bandage over that offers the greatest security."

4. When indicated splinting of the parts with plaster or other available splints should be done. This is particularly needed when muscles or tendons have been cut.

- 5 In combat zones as mentioned before no attempt should be made to close wounds or to suture divided tendons or nerves.

The following notes from the Egyptian campaign are of value in warning against primary suture of War Wounds.

Despite the fact that primary suture in forward units is not advisable and may be disastrous, but re- or partial suture of large sucking wounds has been attempted. The Middle East campaign showed that wounds were found to arrive with base extremely septic so that the stitches had to be removed leaving once more sucking heat and complicated by cell lysis of the chest wall and tissues that could no longer be approximated. The British advice that

these wounds be trimmed and hemorrhage arrested but no attempt should be made to close either by sliding flaps or by suture. They must be made airtight by pads of gauze or vaseline gauze shaped to fit the wound, applied over sulfanilamide powder and pressed firmly in position, with small wounds the pad may be secured by elastoplast with a firm bandage over it to apply pressure, with large wounds two or three sutures of stout silkworm gut should be put through the skin edges and tied over the pad. Wounds so dressed arrive with no more than a local infection and will either close under a series of pads or can be sutured when the first reaction of the tissues is over."

Amputation stumps that have been sutured arrive at the base septic even if drains have been used at the angles. While stumps left open are painful and require a long healing period they are preferable. The most satisfactory immediate dressing is vaseline gauze laid on the raw surface and held in place by several sutures holding the flaps but not approximating them. The British consider "the true guillotine amputation which divides all structures at the same level a surgical crime that no military or surgical excuse can condone."

Some of the British are of the opinion that so great has been the controlling influence of internal administration of sulfonamides on the incidence of sepsis that extensive débridement on the scale considered necessary in the last war should no longer be required. The essentials are removal of foreign material and necrotic tissues, and relief of tension throughout the wound track so that deep accumulations may escape more readily to the surface rather than along intermuscular planes. Therefore, in place of débridement the trend has been toward "trimming operations."

The "wound trimming" consists primarily of incision of the skin and fascia along anatomical planes to lay open all portions of the wound and remove rapidly loose tags and muscle shreds. Thereafter local application of sulfanilamide powder and strip of vaseline gauze laid down to the depths of the wound complete the procedure. The skin, considered of all tissues most viable and most resistant to infection, should be left alone. The popularity of the "trimming" method is growing, judged by reports from the Libyan campaign area, and there are increasing warnings in recent medical literature against indiscriminate sacri-

fice of skin. A surgeon can "trim" about 3 cases in the time spent débriding 1, the patients require less anesthetic, return from the operation in better shape, and the wounds appear to arrive at the base in as good condition as when débridement had been done.

TREATMENT OF FRACTURES

In general the principles that apply to the treatment of fractures in civil life still hold. Shock, hemorrhage, or late infection are common causes of a fatal outcome, since all of these factors are favored by transportation inadequately protected by traction splints. The principle of "splint 'em where they lie" still obtains. If splinting is prompt, before muscle spasm sets in the advantages are obvious.

If the fracture be compound, after clothing has been cut away and hemorrhage controlled, an occlusive sterile dressing of adequate size is applied, but no attempt is made to clean or débride the wound. The appropriate traction or coaptation splints are then applied depending upon the location of the fracture. If a fracture or a wound involves a joint, the treatment is the same as for a compound fracture, no attempt is made to clean or débride the wound. As soon as splints have been properly applied transport to a hospital for definitive treatment is in order.

Short plaster affording inadequate immobilization is a serious fault that has been observed at the battle front. For injuries of the hand or wrist plasters should extend from metacarpal neck to the head of the radius, those of the foot and ankle to beyond the toes and up to the neck of the fibula.

Immobilization of injuries to the thigh and knee joint can be accomplished by a splint called the extension-plaster-Thomas combination, spoken of as the "Tobruk plaster." After any required surgical care has been given to the wound an effective method of applying this splint is as follows:

- 1 Strapping extension is applied on each side of the thigh and leg, with care to avoid circular strips of bandage.

- 2 Traction is then applied to the foot—not the extensions—by an assistant or orderly.

- 3 A broad strong long plaster slab is applied to the posterior part of the thigh and

calf round the back of the heel, which is well padded and along the sole of foot. The plaster should encase at least half the circumference of the leg and thigh and should be carefully molded to the shape of the limb with the knee supported in slight flexion.

4 A Thomas splint is applied with flannel or canvas "cradles" slung under the thigh knee, and calf from the side bars of the splint the ring being pushed well up to the groin.

5 The extensions are wound once round each side bar and tied firmly to the end of the splint.

6 Two large rolls of wool are placed on each side of the thigh to support the site of injury. The bony areas of knee and tibia are padded.

7 A circular plaster is applied round every thigh bars of Thomas, canvas supporting cradles, leg thigh etc.

The traction used is fixed to the end of the Thomas splint, the counter traction being the ring of the splint on the ischiopubic ramus. Longitudinal movement of the leg in the plaster is necessitated only if the extensions slip and this should not occur during the first week if the splint is carefully applied. It must be emphasized that this method is for transport only and not to be used for the treatment of the injury.

The precautions are (1) careful padding of bony points and the back of the heel (2) placing the foot at right angles (3) placing the knee in 15 to 20 degrees flexion, not more otherwise transport is more difficult and swelling of the foot may occur (4) getting the extensions tight before applying circular plaster.

Alternate method is to use a complete plaster instead of a plaster slab. If this is done precautions are (1) splitting plaster before final fixation (2) seeing that the extensions pass easily through holes in the plaster near the ankle—and do not pull on the plaster itself—otherwise sores on the dorsum of the foot and back of the heel are inevitable.

Injuries of the humerus were transported in plaster extending from the acromion down to the wrist. It was found that to transport these casualties in this manner was most uncomfortable and that the method failed to maintain immobilization of the fracture site. It was

found that a comfortable method particular for transport consisted in maintaining fixation by a "U" plaster extending from the base of the neck over the point of the shoulder down the outer side of the upper arm, under the olecranon and upper part of forearm finishing on the inner side of the upper arm just short of the axilla. The arm is then bandaged to the thorax by means of two or three plaster bandages a collar and cuff complete the support to forearm and wrist.

In badly comminuted fractures, especially when damage to the radial nerve is present, long plaster slab on the volar aspect of the forearm and hand is necessary as additional support. This should be fixed to the forearm by a cotton bandage which does not extend lower than the wrist joint.

The notes made on the plaster by the surgeon who first treated the wounded man were of invaluable aid to the next surgeon to see the patient, as it helped him to assess the surgical disposal of the patient on arrival. These sketches are made with indelible pencil directly on the wet plaster.

PERIPHERAL VASCULAR INJURIES

These are among the most important injuries received in combat zones, for there is the risk of life from profound hemorrhage and of limb from inadequate circulation in cases in which a major vessel is involved.

One of the most urgent first aid measures is the arrest of hemorrhage from a large vessel by means of a tourniquet. If one is applied it should be just tight enough to compress the artery but no tighter and the time of its application should always be recorded on the record tag accompanying the patient. If it seems probable that the limb will have to be sacrificed it is best to apply the tourniquet close to the wound. In either event the tourniquet should be released for a few minutes every hour and pressure over the wound applied while it is loose.

The experiences of Allen and Brooks on the survival of tissues deprived of their blood supply and reingenerated at 5 degrees C have prompted the use of this cooling method in cases of major vascular injury. Holman suggests that 3 practical steps in the packing of tour-

niquetted limbs in ice bags before and during transportation would permit the tourniquet to remain in place for 5 or 6 hours without harm to the tissues, and would reduce shock, provide comfort during transportation, and inhibit bacterial growth in the wound.

Direct control of the arterial bleeding by digital pressure is preferable if practical, it is generally adequate unless a major vessel is involved. If the main artery is divided, comparison of arterial pulse on the affected and on the normal limb will confirm the suspicion. An additional test to show the presence of collateral circulation is to make pressure on the main vessel distal to the injury and see whether any color remains in the tips of the extremity.

Additional measures to be taken are to heat the body but not the affected extremity, the latter may be protected from heat loss with woolen coverings. Treatment for shock is given as previously outlined. Injection of $\frac{1}{2}$ grain of papaverine intravenously may be of value in overcoming vasospasm in the collateral blood vessels. Paravertebral block, if feasible, is a better method of attaining the same result.

Ligation of injured vessel. The vessel may be ligated directly in the wound itself after the wound is enlarged to gain adequate exposure; the débridement can be accomplished at the same time. If this is deemed to be impractical or too difficult, the vessel thought to be involved may be exposed far enough proximal to the point of injury to permit a clean dry field. Division between ligatures rather than ligation in continuity is preferable as it causes peripheral vasodilatation, companion veins should also be divided. If an artery is found to be thrombosed, the segment thrombosed should be excised, with the companion vein.

The following illustrations are useful to indicate the incision, the approach, and the collateral circulation in wounds of important arteries, also the dangers of ligation of arteries in continuity and the relatively greater danger of serious hemorrhage from a tangential wound of an artery than from one that completely severs it.

Arterial suture. The opportunities for successful suture of wounded arteries in combat

zones are believed to be very few, the indications for and advantages of such attempts are highly problematical. Those interested in confirming these views should read the conclusions of Mitchiner based on cases of arterial repair by suture in the last war. Holman points out the need for ideal conditions when arterial suture is to be attempted: "absolute asepsis, proper instruments and facilities, and the availability of heparin continuously administered for 24 hours after operation." It is obvious that such ideal conditions seldom exist in zones of combat. Hence, double ligation of the vessel above and below the site of injury and division is the preferable method of controlling bleeding.

Other vascular injuries. Occasionally a wound close to but not directly injuring an artery has been associated with a localized segmental spasm of the artery. Both English and French writers have reported such cases calling them "concussion" or "stupeur" of the artery. This may disappear in 24 hours. Such wounds are débrided of surrounding traumatized tissue and a periarterial sympathectomy is done above and at the site of the spasm.

Contusion of an artery may cause subsequent thrombosis which may extend distally or liberate an embolus, and in either case be followed by massive gangrene. Or the contused area may be the site of a necrosis with secondary hemorrhage and if this is external through the wound may result in death of the patient. If it occurs internally a pulsating hematoma will be produced which may if not treated cause a sacculated aneurysm.

One of the rules in the official history of World War I reads "when a large vessel is exposed in an open wound and has obviously suffered contusion and is thrombosed, the vessel should be ligated above and below the thrombosed segment and the latter excised. This eliminates the danger of embolism, of secondary hemorrhage and vasoconstrictor influences affecting collateral circulation."

TREATMENT OF BURNS

This subject is of great importance since the nature of modern warfare, both on land and at sea is such that severe burns are relatively common injuries. Injunctus was given to the

work of the Subcommittee on Burns of the National Research Council by reason of intensive study of the cases received from the tragic Boston night club disaster. The recommendations of this committee for treatment of burns in the armed forces have been embodied in War Department Circular Letter 15 and circularized to every officer in the medical corps of the Army. An outline follows.

Fundamentals of treatment of burns

- 1 Prevent and control shock.
- 2 Prevent infection pyogenic, tetanus, gas gangrene
- 3 Relieve pain

The control of shock implies prompt and free use of plasma or if available concentrated human serum albumin. If parenteral fluid replacement is required 5 per cent glucose in sterile distilled water is used.

Chemotherapy in all moderate or severe burns should be given prophylactically and for this purpose sulfadiazene is the drug of choice. The initial dose is 4 grams. Thereafter maintenance dosage should be carefully decided by the medical officer with due regard for kidney damage due to the burn and the increased risk of renal complications of sulfonamide therapy.

Tetanus prophylaxis is indicated in cases of second or third degree burn.

Pain requires large doses of morphine and ordinarily $\frac{1}{4}$ grain is required. If there is pronounced anoxia the dosage should not exceed $\frac{1}{4}$ grain.

Local measures—first aid treatment of burned area

1 Since a burn is a large open wound and as such is subject to contamination by organisms from nose and throat all personnel in the first aid room should be masked to minimize contamination from this source.

2 Burned surfaces should be covered with liberal amounts of sterile boric ointment or vaseline followed by strips of fine mesh (bandage) gauze. Over this a smooth layer of sterile dressings (first aid dressings) should be firmly applied and pressure maintained by even bandaging with muslin, gauze, or some elastic type of bandage.

3 It is assumed that the administration of adequate amounts of plasma has been a first consideration.

Definitive treatment of burned area. This consists in the following:

1 Under regular operating room precautions to maintain asepsis, including masking of the patient all grease should be removed by ether, benzene, lard, or other detergents. The burned area and then the surrounding skin are to be cleansed with a bland nonirritating soap and water and soft cotton pledgets but no brushes. Tincture of green soap is not to be used.

2 Blisters should be removed as well as loose bits of epidermis. Skin that is obviously destroyed throughout its full thickness should be excised but if in doubt delay for several days is justified until it is obvious that damage to all layers is irreparable when excision can be done as a secondary procedure.

The wound can then be handled as any open surgical wound with primary skin grafting carried out if conditions are suitable. The measures outlined are usually painful and a general anesthetic is necessary. Intravenous sodium pentothal is the anesthetic of choice.

3 Dressing of the wound involves the use of an ointment, i.e. boric ointment or vaseline, strips of gauze and a thick smooth layer of sterile gauze cotton mechanic's waste or cellulose. The application of firm evenly applied pressure is best accomplished by stockinet or some type of elastic roller bandage. Once applied the dressing should be left undisturbed for 10 days, barring complications. Emphasis is placed on the importance of firm pressure on burns involving the hands, feet, and face. It is desirable to use splints further to immobilize the affected parts.

The necessity for special nursing care for these burned patients is emphasized.

While skin grafting at as early a stage as possible is highly desirable it cannot always be done in the combat zone.

ABDOMINAL WOUNDS

It is an accepted principle that because of the extremely unfavorable prognosis in patients with complicated abdominal injuries and because of the time consumed in operating upon them it is not permissible to operate on such men to the exclusion of a greater number of less complicated casualties. Unlike the out-

come in wounds in other areas the majority of men with complicated abdominal wounds will not survive without early skilled operation and specialized after treatment. The introduction of sulfadiazene paste through the abdominal wound and the setting up of a blood drip to be continued in the plane or ambulance are considered by the British to be measures that may improve the patient's chances in case he must be transported. Patients operated upon for abdominal wounds should not be evacuated until they have had a chance to recover from the immediate effect of the operation and are clearly on the mend.

If conditions permit, wounded men presenting obvious or even suspected penetrating wounds of the abdomen should be subjected to laparotomy unless so extensive that intervention is clearly futile, an exception would be cases of simple penetrating wound of the liver in which nonoperative measures would be preferable.

Death following gunshot or other wounds of the abdomen results from shock, hemorrhage, and infection alone or in combination. Even in cases in which penetrating wounds of the abdomen are due to small sized missiles, the possibility of serious hemorrhage from blood vessel injury or gaping wounds of the intestine makes laparotomy advisable. A rectal examination and examination of the urine should never be overlooked and a radiographic examination which may reveal a foreign body or free gas in the peritoneal cavity should be made. Wounds of the upper abdomen require less prompt intervention than those of the lower abdomen, hemorrhage from penetrating wounds of spleen or liver which tend to be self-limited and perforation of the hollow viscera are less frequent than in wounds of the lower abdomen.

Treatment consists of the following

- 1 Preoperative Rapid, gentle transport with maintenance of body heat, relief of pain and shock, and administration of sulfonamides, catheterization if patient cannot void.

- 2 Operative The choice of anesthesia is important and unless blood pressure is extremely low spinal analgesia is satisfactory. If used, however, circulation should be supported by concurrent transfusion of blood or

plasma or glucose and saline infusion to counteract a further fall in blood pressure due to relaxation of the arterial bed. Control of bleeding points and inspection of organs for injury should be speedy but careful. Simple type of closure should be done, resection should not be resorted to unless conditions compel it.

When injuries to the intestines have been repaired and the peritoneal cavity has been soiled, complete rest of the alimentary canal by slow intravenous infusion and Wangensteen suction is almost indispensable. If the tube is introduced by the anesthetist before the abdomen is closed and its end is manipulated by the surgeon so as to be distal to the lowest repair in the bowel the effectiveness of the suction is enhanced.

The British accomplish gastric suction by use of a Ryle tube passed through the nostril and connected to an inverted vacoliter bottle filled with water and suspended above the bed. A second tube from the vacoliter leads to a water seal on the floor. By the use of a tube 4 feet long the upper coils of small intestines are kept decompressed.

Attention is again called to the fact that men with abdominal wounds withstand travel worse than do those with any other type of injury. Such casualties should be operated upon as far forward as it is possible to place an expert team and, after operation, they must not be moved to the base for from 4 to 10 days until they have recovered their equilibrium. The air evacuation of many patients in the earlier battles of the war in Africa, after relatively simple abdominal operations, resulted in death. Now the practice is to send a certain number of beds to each forward center for abdominal cases.

Time spent in resuscitation of patients with abdominal wounds generally lessens their chances, if there seems any prospect for survival the operation should be commenced as soon as a pint of blood has been given. During operation a blood drip can be administered.

No matter how trivial injuries to the large intestine are they must be exteriorized or drained. If the segment injured can be mobilized it should be resected and the ends brought out as a double barrelled colostomy. If it is

fixed the injury should be repaired and a proximal colostomy done. Any injury to the rectum also demands a proximal colostomy. The principle of exteriorization of colon in junes is certainly one of the most important advances of recent war surgery. The mortality rate has been greatly reduced, being around 50 per cent where it had been 70 to 90 per cent, depending on type of case.

In cases of considerable soiling a small tube, size of a No. 10 F catheter is put down to the site of greatest soiling and brought out through the incision. When the operation is completed 10 grains of sulfadiazine in 50 cubic centimeters of saline is injected slowly the tube is then tied across and tucked into the dressings. On one or two subsequent occasions more drug is introduced if events seem to indicate it and the tube is finally withdrawn. The use of the Fowler's position, continuous gastric suction and fluids by vein are essential in all cases having had intestinal tract injuries or peritoneal soiling.

CHEMOTHERAPY

Chemotherapy is one of the greatest single factors influencing the surgery of this war but it is too broad a topic to consider in any detail here. The results of its use in the recent El Alamein battle are beginning to be known. All wounded were given sulfonamides by mouth from the time they reached the battalion aid post until they arrived at the base hospital. Of 1400 cases evacuated who were wounded in the first 12 hours and reached base hospitals within 36 hours without previous operation, only 46 required urgent treatment on arrival. There were only about 20 cases of anaerobic infection, only 2 or 3 of real gas gangrene.

The value of chemotherapy for war wounds in which there is already an established infection is questioned by many. In a recent trial of sulfasuxidine in the form of a 20 per cent paste in lanolin for such cases there are favorable reports of its effect on the infection. Certainly its theoretical advantages are obvious, namely low rate of absorption, lack of toxicity and irritation and prolonged action. It also is effective against a variety of organisms including the coliform group.

In abdominal cases in which sulfonamides have been instilled into the peritoneal cavity there is no need for supplementary oral administration for 3 to 5 days. The urinary output should be kept between 1500 and 2000 cubic centimeters.

Packets of sterile sulfa compounds should be a part of every surgical set up.

HEAD WOUNDS

A lesson learned by the English in their dealing with air raid casualties was that even minor scalp wounds should be explored for evidences of intracranial injury even though the patient's symptoms might never lead one to suspect a serious injury.

Scalp wounds without skull fracture should if seen early be debrided and closed with interrupted silk sutures. If closure is not practical the wound may be covered with vaseline gauze dressings after thorough cleansing and removal of dirt, hair and foreign bodies.

Severe head wounds—those involving skull fracture with penetration of dura—require speedy evacuation to a hospital. A minimum of handling and great gentleness are desirable.

SPINE WOUNDS

Don't jackknife the patient—slide or roll onto the stretcher without lifting. Do not permit head to be rolled around or neck flexed in injuries to the cervical spine.

No debridement or suture of these wounds in the forward area is advisable. Such patient require immediate evacuation to a well equipped hospital. Speed in such transfer means prevention of a fatality or a permanent paraplegia.

PERIPHERAL NERVE WOUNDS

Injuries to peripheral nerves are chiefly of two forms (a) those caused by a through and through bullet or shell fragment, and (b) wide lacerated wounds. The former require sterile dressing after the usual cleansing. The latter should have free irrigation with normal saline solution to rid wound of particles of dirt and foreign material.

Do not suture nerve wounds at time of injury as part of a primary debridement except in cases where it lies exposed in the wound and

time permits. Even under these conditions the wisdom of suture at time of debridement is open to argument. Certainly extensive dissection and immobilization of nerve ends to permit suture is never permissible. Procedures of such a nature should be carried out only in hospitals.

Immobilization of the involved extremity in the position causing least retraction of the nerve ends is desirable during transfer.

SUMMARY

1. Treatment of wounds in the combat zone follow the general principles that are accepted for surgery in times of peace.

2. Factors that alter the details of surgical treatment are those enforced by circumstances attendant upon conditions of warfare.

3. Shock, hemorrhage, resuscitation, wounds of soft parts, fractures, burns, vascular, chest, abdominal wounds, debridement and chemotherapy have been discussed briefly in relation to the general subject.

4. It seems obvious that the military surgeon in the combat zone must add to his qualities of courage and competence, resourcefulness and an ingenuity that will permit him to extemporize when necessary. He must be one to whom the urgency of a situation serves only as a challenge to meet it. He must not only know the truth of the saying "first things come first" but must be able to recognize which are the things of first importance. He must adopt the slogan and apply it to his own work. "The difficult we do immediately — The impossible takes a little longer."

SURVEY FILM DIAGNOSIS OF ACUTE SURGICAL ABDOMEN

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THE diagnosis of intra abdominal surgical conditions may be baffling not only to the internist but to the surgeon as well. Clinical signs and physical findings are sometimes ill defined or absent thus making a definite decision difficult in a questionable surgical abdomen. Considerable aid may be obtained from survey films or so called flat plates of the abdomen. A minimum of 3 films should be taken, a high and a low supine film and an upright film. In cases in which the patient's condition permits films in the prone and lateral decubitus positions are advantageous.

When a perforated viscus is suspected, an upright film is most informative (Fig. 1). Free air beneath the right leaflet of the diaphragm is pathognomonic of a ruptured viscus. The amount of air may be considerable or minimal depending upon the size of the perforation and the rate of escape of gas. The greater the interval of time between the onset of symptoms and the roentgenoscopic examination, the greater the likelihood of positive findings and the larger the accumulation of air. When the differential diagnosis lies between a perforated peptic ulcer and a ruptured appendix, in the presence of a spreading peritonitis one cannot say with any degree of finality whether it is one or the other simply because there is free subdiaphragmatic air since ruptured appendices and ruptured intestinal diverticula may also yield the same finding. It is fair to say however that ruptured peptic ulcers are much more often the etiological factor of free intraperitoneal air. One should emphasize the fact that when a patient is roentgenographed shortly after the onset of symptoms no free air may be seen and the surgeon should be guided by clinical findings as to the handling of the case. If fluoroscopy is negative an upright roentgenogram should be taken, since minimal collection of air may be seen on the film and missed on fluoroscopy. When the air collects beneath the left diaphragm it may be

confused with the *wagenblase* to obviate this a right decubitus film should be taken.

In obscure cases with abdominal symptoms in which coronary thrombosis must be differentiated as the underlying cause of the abdominal findings, an upright survey film is of great aid to the attending surgeon and is very often life saving.

Therapeutic pneumoperitoneum administered occasionally in tuberculous patients will confuse the issue when a surgical problem presents itself. After laparotomy free intraperitoneal air will persist for about 10 days and should be discounted in any given case. In hepatocolic interposition a condition in which a loop of colon lies immediately subjacent to the right diaphragm one should be extremely careful in the interpretation of the upright film. The presence of haustral markings will aid in differentiating this condition from free subdiaphragmatic air.

The diagnosis of intestinal obstruction is often made or corroborated by a survey x-ray film (Fig. 2). In small intestinal obstruction the loops assume a step-ladder appearance, are dilated and very often present a hair pin turn. If there is marked small intestinal dilatation the involvement is most likely jejunal since more secretory activity occurs in the jejunum than in the ileum. The more proximal the intestinal obstruction the greater the degree of intestinal dilatation. It is usually abnormal to find gas within the small bowel, so that *a priori* when clinical signs of obstruction are present this finding should be regarded with suspicion. Trapped gas in one isolated loop of small bowel may be the earliest manifestation of obstruction and one is cautioned not to delay treatment until all the diagnostic criteria are present for that may spell disaster to the patient. The presence of a fluid level in the upright film is an additional valuable sign of obstruction however considerable difficulty may be experienced in obtaining satisfactory upright films in ill patients. Gas in intestinal obstruction may be due to

From the Surgical and X-ray Departments, Jewish Hospital



Fig 1 In this roentgenogram is shown a small collection of air beneath the right diaphragm due to perforated duodenal ulcer



Fig 2 Typical fully developed small intestinal obstruction with characteristic step-ladder appearance. Dilatation involves jejunum. Note prominent valvulae conniventes

ingestion diffusion through the bowel wall and putrefaction. Ingested air may traverse the small bowel in 6 to 15 minutes.

It is often rather hard to distinguish between small and large intestinal loops, and a posteroanterior film may be very helpful. The small intestinal loops are diffusely located throughout the abdomen, whereas the colon has more of a peripheral distribution. Definite identification of haustrations indicates colonic involvement, but one must be careful not to confuse these with pseudohaustrations seen in dilated small intestinal loops.

The presence of gas in both the small and large bowel bespeaks either an obstruction that has released itself or a partial obstruction. A similar appearance may be produced by morphinization. Morphine (1) affects the duodenum greatly, the duodenum is first constricted and then dilated. In susceptible individuals one repeatedly observes accumulation of gas in both the large and the small bowel. To discount the effect of postoperative morphinization the drug should be withdrawn and the patient again roentgenographed for any change in the intestinal gas pattern. Ord-

narly (2) the ileocecal valve blocks the egress of gas from the small into the large bowel. In sigmoidal obstruction of long standing there may be regurgitation of air into the cecum with marked distention or even rupture of the cecum (Fig 3). Tremendous dilatation of the cecum on survey films should arouse the sus-



Fig 3 Markedly dilated cecum produced by obstructing carcinoma of rectosigmoid



Fig. 4. Right subdiaphragmatic abscess. Fluid level within abscess cavity.



Fig. 5. Subhepatic abscess displacing duodenal cap to the left and the hepatic flexure downward.



Fig. 6. Acute intussusception. Note telescoping of bowel into the transverse colon resulting in double columns of colonic gas. Loops of cecum and ascending colon are absent from usual habitat.

tion of a low colonic obstruction (Fig. 4). If a subdiaphragmatic abscess is suspected it is imperative to make upright, supine, and prone films with the Bucky diaphragm and also lateral decubitus films. In a well defined abscess there is a fluid level seen only in the upright position. A lateral view is necessary for more precise localization to aid the surgeon in the proper surgical approach to the lesion. Upon fluoroscopic examination if elevation of the diaphragm and restricted excursion combined with pleural effusion or basal pneumonia are seen, it is cause for increased suspicion (Fig. 5). Subhepatic abscess may be suspected when there is a dense shadow confluent with the lower border of the right lobe of the liver displacing the stomach and duodenum to the left and the hepatic flexure downward.

Parenchymal abscess may be suspected when there is obliteration of the ileopsoas line, a scoliosis of the lumbar column away from the affected side, an indistinct kidney image, and a restriction in the upright posture of normal kidney mobility. Often there is a ballooning of the psoas mass and this finding should not be ignored but reported.



Fig 7 Lacerated spleen. Markedly serrated greater curvature of cardia of stomach. Widened gastrocolic omental space due to hemorrhagic infiltration



Fig 8 Volvulus. Markedly dilated loop of sigmoid ascending to right upper quadrant. Note reduplication of colonic loops

A pelvic abscess may offer diagnostic criteria by the presence of a homogeneous opacity in the region of the pelvis coupled with an upper abdominal ileus. Depending on the size of the abscess, upward degrees of displacement of loops of bowel are observed. Roentgenologically pelvic abscess must be differentiated from ovarian, uterine, and retroperitoneal tumors. The latter are usually more sharply defined and circumscribed than in pelvic inflammatory disease. An ovarian dermoid reveals itself through the presence of calcifications, teeth, and fluid levels of varying densities.

Intussusception yields the usual x-ray findings of intestinal obstruction, and often one may actually visualize the intussusceptum and the intussusciens (Fig 6). We have observed in several cases the telescoping of the bowel loops, usually the ileum within the ascending colon or transverse colon. As the intussusception develops there is a paucity of small intestinal loops away from the site of the lesion. In cases of subacute intussusception with spontaneous reduction we note an ever



Fig 9 Gastrectasis due to tuberculous adenitis. Dilated stomach occupying greater part of the abdominal cavity. Caused by complete duodenal obstruction due to retroperitoneal tuberculous glands.



Fig. 6. Abdominal aortic aneurysm. Clinically it also related an acute lateral surgical abdomen ruled out by acute illness. Calcified rim at periphery of aneurysm.



Fig. 7. Ruptured liver in retroperitoneal portion of the duodenum. Note crescentic collection of air about duodenal cap.

changing picture as the obstruction appears and disappears.

Survey film examination is very helpful in traumatic cases. In a great many normal subjects examination delineates the splenic shadow in the left upper quadrant (Fig. 7). It is sharply defined against the outline of the adjacent stomach especially when the latter is filled with gas. In a lacerated spleen the blood gravitates along the gastrosplenic ligament between the folds of the gastocolic omentum thus may produce one or several of the following helpful hints toward arriving at a precise diagnosis. The greater curvature of the stomach assumes a serrated appearance because of the juxtaposition of the adjacent hematoma. The stomach is displaced to the left and the transverse colon downward.

There is an increase in the size of the splenic shadow especially in cases of intracapsular splenic hemorrhage. The splenic shadow usually merges with the opacity extending into the region of the gastocolic omentum resulting in further separation of the two air distended hollow viscera. In case of shock follow-

ing lacerated spleen gastrectasis is an associated finding the stomach ballooning out with a large amount of air.

Lacerated livers are characterized by splinting of the right diaphragm on respiration, enlargement of the hepatic shadow, an ill defined lower hepatic border, and a displacement of the stomach to the left when the right lobe of the liver is lacerated.

Mesenteric thrombosis yields a picture similar to that of ileus. In the majority of our cases the small intestinal loops have been only slightly dilated and the degree of intestinal dilatation has been less marked than in obstructive lesions. Mesenteric abscess produces a homogeneous radio-opaque shadow with no the peritoneal cavity surrounded by dilated small intestinal loops.

Occasionally small intestinal obstruction in the elderly patient is due to a gall stone which has entered the small intestine via a cholecystoenteric fistula. A survey film reveals the usual x ray signs of obstruction plus the presence of a calculus within the small intestine. Therefore the film enables one not only

to make a precise etiological diagnosis but also to localize the site of obstruction. An additional clue to cholecystointestinal fistula is the presence of striated air shadows within the biliary ducts. These may be disseminated over the entire liver or may constitute only a few isolated streaks over the right lobe of the liver.

Volvulus, a rare condition, has been diagnosed by us several times on the basis of survey x-ray films (Fig 8). Usually one finds markedly dilated loops of large intestine particularly near the hepatic flexure. Since volvulus is invariably associated with considerable elongation and reduplication of the sigmoid, which often ascends diagonally to the right subhepatic region before making a downward swoop, one finds on careful analysis of the film multiple vertical loops of large intestine in the normal habitat of the ascending colon. Extreme degrees of large intestinal dilatation are seen in volvulus. Dilated loops of small intestine having an arcade arrangement suggest a small intestinal mesenteric volvulus, rotated about an adhesive band.

In tuberculous adenitis one may encounter on occasions complete duodenal obstruction resulting in marked gastrectasis (Fig 9). In one of our cases retroperitoneal tuberculous glands caused complete duodenal obstruction because of periduodenal adhesions. The stomach was huge, occupying practically the entire peritoneal cavity simulating a pneumoperitoneum. The patient died rapidly in severe alkalosis (Fig 10). A ruptured abdominal aneurysm may simulate an acute surgical abdomen. The survey film shows a diffuse homogeneous density to the left of the lumbar spine obliterating the left ileopsoas line. Very often one notes either calcific debris within the mass or fine arteriosclerotic plaques within the wall of the aneurysm.

On several occasions not only a false diagnosis of some intraperitoneal surgical condition was avoided but also a useless operation.

While an extended discussion of intra-abdominal intestinal lesions in the newborn cannot be undertaken here, a few words may be helpful. Congenital small intestinal anomaly may be suspected by the presence of large amounts of small intestinal gas. In two of the



Fig 12 Reflex ileus secondary to acute cholelithiasis. Spontaneous recession after cholecystectomy.

infants there was marked distention of the cecum and ascending colon due to congenital bands extending from the right lobe of the liver and constricting the right half of the transverse colon. Complete or partial intestinal atresia may be suspected from a survey x-ray film. In atresia of the sphincter ani, it may be advantageous to examine the baby in complete Trendelenburg position; one notes distention of the large bowel including the rectal ampulla, the column of air stopping short of the anus (Fig 11).

CONCLUSION

Survey x-ray films of the abdomen are very helpful in arriving at a diagnosis in intra-abdominal surgical conditions. In spite of diagnostic limitations, these films very often aid in arriving at a precise conclusion in baffling cases.

CASE 1 Baby girl T was delivered normally, uneventfully, and spontaneously, 48 hours before onset of symptoms. On January 14, 1940, the infant vomited greenish material, the abdomen was distended, and colonic irrigation resulted in passage of meconium and reddish black material. Physical examination revealed moderate distention, with soft coils of intestine discernible at times. Peristalsis was hyperactive. Survey film of the abdomen showed marked small intestinal distention. A suggestion of

step-ladder appearance corroborated the clinical diagnosis of intestinal obstruction and indicated that we were dealing with a small intestinal anomaly. At operation a complete stricture of the jejunum was noted. Enterocentrostomy was done but the child died 3 days after operation. Postmortem examination revealed again congenital stricture of the jejunum, patent midline duct, low grade peritonitis and renal hemorrhage.

CASE 2. K. M., a middle aged woman complained of severe lower abdominal pain. Physical examination revealed a considerable amount of tenderness and some rigidity in the hypogastric region. Peristalsis was normally active. Auscultation revealed a bruit. Survey film of the abdomen showed large aneurysmal dilatation of the lower end of the abdominal aorta. Thus we were able to make a precise diagnosis. The survey film in this instance justified an unnecessary intra-abdominal operation.

CASE 3. R. C., aged 57 years, was admitted to the hospital December 9, 1942. The diagnosis then was intestinal obstruction. Patient complained chiefly of pain in the right upper and right lower quadrant. On December 9, patient awoke with pain, increasingly severe and constant. She had not had bowel movement since December 8; she had complained of chronic constipation for months and, for the past 3 days, of loss of appetite and vomiting. Physical examination showed considerable rigidity and tenderness in the right upper quadrant. There was a moderate degree of distention, and a soft palpable mass was elicited in the right upper quadrant. The blood count showed moderate leucocytosis; hit blood cells, 3,800 polymorphonuclears, 88; van den Bergh showed direct, negative, and indirect 6 milligrams. Survey film of the abdomen showed a large amount of small intestinal distention. There were numerous small intestinal coils in the left abdomen. In addition to that, there was a large radio-opaque stone on level with the fourth lumbar vertebra. This was strongly suggestive of gall stone. At operation on December 10, a large stone in the gall bladder as well as an acute cholecystitis was revealed (Fig. 1). Patient was discharged December 24 in good condition.

CASE 4. L. K., boy aged 6 years, complained of intermittent colic-like abdominal pain. Physical examination revealed in the epigastrium a mass which would appear and disappear. Symptoms were most pronounced at the time the mass was palpable. There was no evidence of bloody stools or diarrhea. Survey film of the abdomen revealed evidence of intussusception. There were a number of distended loops of small bowel in the left portion of the peritoneal cavity. In the right side of the peritoneal cavity

there were practically no intestinal loops. Careful examination of the survey film showed evidence of an intussusception and intussusciptions in the right upper quadrant. We noted double column of air within the small bowel, one of the loops of the bowel being telescoped into an adjacent loop. The diagnosis was intussusception. At the time of operation the surgeon found intussusception caused by a lymphosarcoma of the terminal ileum. A resection with ileocolostomy was done. Patient made an excellent recovery. Microscopic examination revealed lymphosarcoma of the ileum. Patient is alive and well 6 years after operation.

Interesting feature of this case was the appearance of secondary metastasis in the humerus about 18 months subsequent to operation. Changes in the humerus responded very nicely to radiation.

CASE 5. H. J. H., aged 4 years, was admitted to the hospital December 15, 1942. His chief complaint was pain in both testes, the left and in the epigastrium. The pain began 1 day prior to admission, and had increased in severity. There was moderate abdominal distention. The patient voided twice prior to admission. He had had no bowel movement for 7 days. This portion of the history was rather unreliable as the patient was a vagabond and homeless. Physical examination showed a moderately distended abdomen, on palpation there was tenderness in both loins. There were no palpable masses. Peristalsis as present. The clinical diagnosis was possible intestinal obstruction. The precise cause of the intestinal obstruction could not be determined. A survey film of the abdomen showed diffuse, large intestinal distention. The sigmoid particularly was elongated and could be followed to the right upper quadrant. There was marked reduplication of the sigmoid. A pre-operative diagnosis of volvulus was made and this diagnosis was corroborated at operation.

The obstructed loop of sigmoid was resected and Miller operation was done. Patient made satisfactory recovery.

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FRISH FRACTURES OF THE CARPAL SCAPHOID

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FRACTURES of the scaphoid bone occur almost exclusively in young men, some military. They are rarely seen in children, and are not common in old people. The incidence of this fracture is about 1 per cent of the fractures of the wrist. This report is based on a study of age, sex, and type of fracture which occurred in twenty-four military scaphoid fractures of the wrist.

CHARACTER OF THE SCAPHOID BONE

The scaphoid bone has a number of peculiarities which have directed attention to its importance in the study of these fractures. It is the largest bone in the proximal row of the wrist, and is the only bone in the proximal row of the bones of the hand which is not connected to the other bones of the wrist. It is the only bone in the proximal row of the hand which is not connected to the other bones of the hand.

From its position, it is evident that the scaphoid is found to be the only bone in the proximal row of the hand which is not connected to the other bones of the hand. It is the only bone in the proximal row of the hand which is not connected to the other bones of the hand. It is the only bone in the proximal row of the hand which is not connected to the other bones of the hand.

O'Brien and Hall have studied the blood supply of 207 carpal scaphoids and found that every specimen had at least a few arterial foramina in the tubercle and distal portion. In 67 per cent of the bones there were arterial foramina along the entire length of the bone adequately supplying both the proximal and distal portions. In 13 per cent there were no arterial foramina proximal to the wrist. They concluded that a fracture through the wrist of the bone could interrupt the blood supply to the proximal fragment in between 13 and 33 per cent of the cases (Fig. 1).

MECHANISM OF FRACTURE

In most instances the soldiers report that they fall or are thrown to the ground, and in attempting to break the fall land on their outstretched hands, occasionally on the heels of their hands. Usually the heel of the palm is the first to strike the

ground. There is a strong impact as the wrist receives the blow, but the wrist does not hyperextend, for it is rigidly fixed by the soldiers or by the ground. The impact cracks the scaphoid bone at its mechanically weak point, the wrist. Of the 24 fractures, 22 were through the wrist. Except for the scaphoid all the carpal bones are roughly cuboid in shape and have no weak points. The impact which cracks the scaphoid does not apparently not sufficient to fracture any of the other carpal bones. Such fractures are reported.

In support of this explanation for the mechanism of fracture is the high incidence of hair line fracture, hyaline, and more distinct fracture lines through the wrist, without anatomical displacement of the fragment. Of 24 all but 3 showed definitely no displacement of the two portions of the scaphoid. It would seem that any element of hyperextension of the wrist would separate the two fragments after the fracture.

This mechanism of fracture also explains the higher incidence of scaphoid fractures than Colles fractures in young male adults. During the same period of study there were only 10 typical Colles fractures among the soldiers in training. In civilian life the relative frequency of Colles fracture to scaphoid fracture is given as 10 to 1 by Scudder. The strong wrist of a soldier does not hyperextend when he falls on his hand but the scaphoid may crack. The weak wrist of a woman, a sedentary worker, or older person hyperextends under the same conditions and a Colles fracture often results.

CLINICAL SYMPTOMS AND SIGNS

In a typical instance, when a soldier falls on his palm and feels pain in his wrist, he reports to his dispensary. The medical officer examines his wrist, sees little or no swelling, finds a tender point in the anatomical snuff box, and checks pain on passive motion of the wrist in all planes. Active and passive motions are restricted because of pain. The soldier thus presenting these clinical evidences of a fracture of the scaphoid bone is referred to the x-ray department for roentgenologic examination.

ROENTGENOLOGY

The roentgenograms are taken of the wrist in

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a, Left



a, Right



b, Left



b, Right



c, Left



Right

Fig. a, The entire length of the scapula is adequately supplied by arterial foramina. 67 per cent of the bones studied by Obleta and Halstead. A fracture through any portion of the scapula does not interrupt the circulation to either fragment. Type I fracture b, In 30 per cent of the scapulae fracture through the

acromion and may or may not interrupt the blood supply to the proximal fragment. Type I or type II fractures c, In 33 per cent if there is no arterial foramen at the distal or proximal to it, fracture will interrupt the blood supply to the proximal fragment. Type II fracture. Courtesy *Journal of the American Medical Association*.



Fig 2 J T C Type I fracture The hairline fracture through the waist, a, does not interrupt the blood supply to the proximal fragment There is mild hyperemic decal-

cification equally involving both halves of the scaphoid at 8 weeks, b The fracture line is completely obliterated 12 weeks after the injury, c.

four positions on a 10 by 12 film The usual anteroposterior and lateral views are supplemented by one anteroposterior view in ulnar deviation and a posteroanterior view in 45 degree oblique Using this four-view technique not even the finest hair-line fracture should escape detection Previous to the routine use of this technique there were several instances in which the standard anteroposterior and lateral views disclosed no fracture, only to have repeated examination at a later date reveal a fracture line which had been missed

The fracture healing of the carpal scaphoid can be followed by serial roentgenograms Once the fracture is recognized in the four-view film the repair process can best be studied in the single ulnar deviation view repeated at 3 to 4 week intervals For each examination the plaster cast is removed and a new one applied if the x-ray shows the need for further immobilization To show the healing process the films must be technically satisfactory In general it has been found better to overexpose somewhat than to underexpose the negative An underexposed film does not show small but important differences in densities

Of the 34 fractures studied, 35 were through the waist of the bone, while 10 were through the proximal pole There were no fractures of the tubercle found in the series studied

FRACTURE PHYSIOLOGY

There are several features of the repair of fractures which are particularly applicable to fractures of the scaphoid

Stirling has shown that during the first 2 weeks fluids taken from fracture sites shows a drop in pH from 7.4 to 4.8 on the 4th day, with a return to normal alkalinity on the 11th day This acidity brings about a localized absorption of calcium salts at the fracture site, causing the fracture line to be wider and more distinct on the roentgenogram taken a few weeks after fracture

Also during the first few weeks there is a reactionary hyperemia which is initiated by the fracture This active hyperemia is believed to be caused by the liberation of minute quantities of histamine and acetylcholine at the site of the fracture As a result of this hyperemia the bones of the wrist undergo decalcification and osteoporosis (Greig, Watson-Jones and Roberts, 14) This decalcification is usually mild but occasionally may be severe The hyperemia subsides normally within 2 weeks, after which time there is a slow return of calcium to the involved bones The process of recalcification is retarded by the fact that the wrist is immobilized in a cast and ordinarily undergoes disuse atrophy For this reason the return of normal density to the wrist as seen on the roentgenogram may be delayed until the fracture is completely healed and active use of the wrist is restored

In those wrists which are not completely immobilized, the repeated trauma at the fracture site causes the hyperemia to be prolonged beyond the usual 2 week period Consequently the decalcification is more pronounced and the return to normal roentgenographic density is delayed

The phenomena of hyperemia producing decalcification is dependent upon adequate blood



a, September 6, 1942



b, October 30, 1942



c, December 4, 1942



d, April 24, 1943

FIG. 3 B. K. Type II fracture. On the day of injury the hairline fracture is seen through the proximal pole a. Six weeks later there is contrasting density between the vascular proximal pole and the surrounding bones, b. This is evidence of interruption of circulation to the proximal fragment. Eleven weeks after the injury the fracture line is barely visible and there is low contrast between the two fragments of the scaphoid c. The final study 36 weeks after the injury shows the fracture to be completely healed. There is callous density in the entire scaphoid, d.

supply to the involved bones. If the arterial supply to a bone or portion of a bone is interrupted during the phase of hyperemia that portion does not decalcify along with the neighboring bones but retains its normal calcium content and its normal radiologic density. This is roentgenographic evidence of avascularity. Steindler believes that the most important factor in the production of nonunion is interference with the nutritive arterial system of the bone.

Johnson has shown that bone repair occurs in the scaphoid in the same way as in the medulla of the diaphysis, but that all bones of this cancellous type heal more slowly than long bones. "This is largely due to the lack of subperiosteal callus formation but is also due in part to the cancellous reaction being less extensive and less active than in the medullary response in the diaphysis."

In the absence of callus formation as a criterion of healing of a fracture, we must rely solely on the radiographic disappearance of the fracture line as evidence of union of the fractured scaphoid. A persisting fracture line beyond 10 to 12 weeks is indicative of delayed union.

If the wrist is not immobilized adequately the continued movement causes a shearing stress between the two fragments of the fractured scaphoid. Under the influence of this shearing and gliding motion fibrous and fibrocartilaginous tissue develops at the fracture site. The bone immediately underlying the new-formed cartilaginous layer becomes sclerotic and eburnated and assumes many of the characteristics of subchondral bone. On the roentgenogram this condition is recognized by the persistent translucent fracture line with a dense white irregular sclerotic



Fig 4 J W C Type II fracture The fracture is through the waist, a At 9 weeks the fracture line demarcates the distal porotic fragment from the dense avascular proximal fragment which does not enter into the

hyperemic decalcification initiated by the fracture, b The final study 23 weeks after the injury shows the fracture line to be completely obliterated The densities of the two portions of the scaphoid are blending, c

margin on either side of the line dividing the cancellous bone of the scaphoid into two parts This picture indicates nonunion of the fracture

TYPES OF SCAPHOID FRACTURES

Based on our knowledge of the anatomical variations in blood supply and our understanding of the physiology of fracture repair, together with a careful study of serial roentgenograms taken 3 to 4 weeks apart, we are able to divide our 45 fractured scaphoids into two groups type I—fractures without interruption of the blood supply to either fragment, type II—fractures with interruption of the blood supply to the proximal fragment

As would be expected from the anatomical studies, the majority of the fractures fall into the type I group, inasmuch as two-thirds of the scaphoids have an adequate distribution of arterial foramina throughout the long axis of the bone

At the first x-ray examination on the day of injury the fracture line is barely visible in many cases The fracture line at the waist is either a hair-line fissure or a more easily recognizable crack There is usually no displacement of one fragment on the other In 4 cases the displacement is barely perceptible The entire scaphoid bone and the surrounding wrist bones show a uniform normal density on the film In one case there was an associated injury to the radius, consisting of a transverse crack fracture 1 inch from the distal end without any displacement In another case there was an associated Bennett's fracture-dislocation of the first metacarpal

At the roentgenographic examination made 3 or 4 weeks after the injury the fracture line is seen to be more distinct than the hairline shadow seen on the day of injury There is mild to moderate diffuse homogeneous decalcification of the cancellous bones of the carpus *including both fragments of the scaphoid* to an equal degree

At the examination made at 6 to 8 weeks there is noted a partial or even complete obliteration of the fracture line In many cases the fracture appeared to be healed within 8 weeks The decalcification process has stopped and there is evidence that some recalcification has occurred, although the entire carpus is less dense than the normal wrist taken for comparison Both portions of the scaphoid maintain a density uniform with the surrounding bones

If the fracture line has disappeared and the cast is removed, a subsequent roentgenogram 4 weeks later shows restoration of the normal density to all the bones of the wrist including the newly-healed scaphoid (Fig 2)

There were 8 fractures of the scaphoid in the type II group, showing interruption of blood supply to the proximal fragment On the first day of the fracture the cases in this group appear identical with those of type I At the second examination made at 3 or 4 weeks, the fracture line is more distinct due to the local resorption of calcium at the fracture site There is evidence of generalized decalcification in all the bones *except the proximal fragment of the fractured scaphoid* This fragment shows the same density as it did on the day of the fracture The fracture through

the waist has interrupted the blood supply to the proximal fragment, thus excluding it from the reactive hyperemic decalcification. This difference in density between the proximal fragment and the distal may not be obvious unless the degree of decalcification is sufficient to afford a contrast.

At 6 to 8 weeks the generalized osteoporosis of the carpus is usually more pronounced than in the type I cases. There is no difficulty at this time in recognizing the difference in density between the proximal fragment and the surrounding bones. The proximal fragment has retained its original calcium and original density and stands out in sharp contrast to the osteoporosis of the adjacent bones. The fracture line is still visible. At 10 to 12 weeks the fracture line shows signs of healing but there is still a noticeable difference in density between the proximal fragment of the scaphoid and the neighboring bones. There may be evidence of beginning restoration of calcium to the carpus.

At 16 to 20 weeks the fracture line has been obliterated by the healing process. The difference in density between the two parts of the scaphoid is less marked. Their densities seem to blend. If the cast is now removed there will be a return of normal bone density to the carpus within a few weeks. Subsequent examinations fail to reveal degenerative changes in the scaphoid. At no time can the mottled density of "creeping substitution" be demonstrated in the proximal fragment (Figs. 3 and 4).

CONCEPT OF TEMPORARY AVASCULARITY

It is very important to distinguish between temporary vascularity of the proximal fragment and aseptic necrosis of this part. The dense white shadow cast by the proximal fragment of the fractured scaphoid in type II cases is evidence of vascularity but not of necrosis. According to Bradford "temporary retention of calcium by a fragment of bone does not indicate that the fragment is necrotic; it may fuse without any of the secondary changes characteristic of necrotic bone."

Experimental studies have shown that bone cells die slowly when deprived of their blood supply. Phemister (6) has shown that some bone cells in a free bone transplant appear to be alive for as long as 6 months. It is very likely that the bone cells in the proximal fragment of the fractured scaphoid do not immediately become necrotic after the interruption of blood supply. If revascularized within a reasonable short time, perhaps 3 weeks, this fragment can remain viable.

This concept of *temporary avascularity* is demonstrated in the type II fracture. Immediately after the fracture is immobilized the healing process begins. Fibrous granulations grow across the fracture site, bringing new blood vessels from the distal to the proximal fragment. This process is fairly rapid and within a few weeks the blood supply is more or less completely restored, in this manner preventing necrosis of the proximal fragment.

At this stage the roentgenogram shows the proximal fragment to have the same density as is seen on the day of injury. It is impossible to tell without microscopic study whether this fragment is viable or necrotic. The rapid restoration of the blood supply to the avascular fragment is not manifested on the roentgenogram for it does not immediately cause a decrease in density. Bone loses its calcium when under the influence of active hyperemia but this phase of hyperemic decalcification has already subsided by the time the proximal fragment is revascularized. Hence the difference in density between the two portions of the scaphoid persists for several months despite the fact that both fragments are viable and have adequate blood supply. As the carpus recalcifies there is gradual blending of densities until there is no visible contrast between the two portions of the scaphoid.

Temporary avascularity of the proximal portion may lead to aseptic necrosis if the revascularization process is inadequate or disrupted. If the event that the wrist is not adequately immobilized the shearing movements at the fracture site prevent the growth of new blood channels into the proximal fragment. The fibrocartilage at the fracture site forms an effective barrier to isolate the proximal fragment from its only source of blood supply. The proximal fragment slowly dies. This is shown in Phemister's case (7) of a nonunion of a waist fracture of a carpal scaphoid which showed a dense proximal half contrasting sharply with the osteoporotic viable distal half and neighboring bones. The proximal half was removed 93 days after the fracture and was found to be necrotic on histological examination.

CLINICAL SIGNIFICANCE OF TEMPORARY AVASCULARITY

Many surgeons have advocated early removal of the proximal portion of fractures of the carpal scaphoid. Watson Jones (11) in his excellent treatise on these fractures believes that only early excision of the proximal fragment which shows complete loss of blood supply can succeed in pre-

venting degenerative arthritis of the wrist. He says that "diagnosis is usually possible within a few weeks of injury and operation should be undertaken at once." Phemister (7) says that "if the necrotic fragment is not removed it may undergo slow creeping substitution, or the interior may be absorbed but not replaced by bone, giving a honeycombed appearance in the roentgenogram. Adhesions, partial necrosis of cartilage, irregularity of articular surface, and chronic arthritis are frequent late results."

The series of roentgenograms in the type II fractures shows that healing does occur in fractured carpal scaphoids despite temporary avascularity, provided the wrist is adequately immobilized. Healing is somewhat delayed. Drilling of fragments and bone grafts as advocated by some surgeons (4, 8, 10) are not necessary. Excision should be performed only when there is positive x-ray evidence of nonunion of the fracture and aseptic necrosis of the proximal fragment as seen by creeping substitution with its irregular mottled density and partial collapse.

TREATMENT

From the foregoing discussion of the healing of fractures of the carpal scaphoid it is evident and imperative that the wrist be immobilized as soon as possible after the fracture. The immobilization must be complete, uninterrupted, and maintained until there is definite x-ray evidence of healing.

In our experience a plaster-of-Paris gauntlet as described by Soto-Hall and Haldeman is the most satisfactory method of giving complete immobilization. The circular cast extends from the distal palmar crease to the elbow and includes the proximal phalanx of the thumb. The wrist is fixed in a few degrees of dorsiflexion and the thumb is maintained in a neutral relaxed position. In this type of cast the fingers can be flexed into the palm and the index finger can touch the tip of the thumb. The soldier is not hospitalized but is encouraged to use his hand as much as possible and to participate in the training program of his group (Fig. 5).

The cast is replaced as soon as it breaks or softens or otherwise fails completely to immobilize the wrist. This is very important during the first month when the fracture repair process is delicate and requires complete protection from shearing stresses. At 3 to 4 week intervals the cast is removed, x-rays are taken, and a new cast is applied. It is discarded only when the fracture is healed. There is no need for physiotherapy to mobilize the wrist after the gauntlet is discarded.

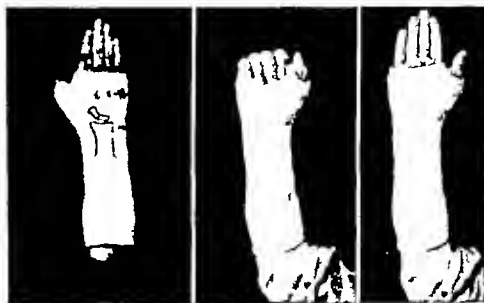


Fig. 5 Plaster-of-Paris gauntlet which affords adequate immobilization to the fractured scaphoid while permitting satisfactory use of the fingers and thumb.

There is a surprisingly rapid return of mobility and power without evidence of disability in these cases.

RESULTS

Of the 45 cases studied, only 28 remained under observation until their casts were discarded. There were no nonunions among these cases. Of the remaining 17 fractures, 12 were transferred to other camps while 5 were still in plaster casts. There was no indication by x-ray that any were developing nonunion. It is believed that adequate immobilization gives equally gratifying results in both types of cases. The average time required for healing of type I fractures was 8.3 weeks. The type II fractures required an average of 19 weeks for disappearance of the fracture line.

SUMMARY AND CONCLUSIONS

1. Fractures of the carpal scaphoid are caused by a fall on the outstretched hand in which the wrist is rigidly fixed by strong forearm muscles and hyperextension or hyperflexion is prevented. The impact causes the bone to crack at the waist and does not ordinarily cause displacement of the fragments.

2. Depending on the anatomical variations in blood supply to this bone, a fracture will not interfere with the blood supply to both fragments (type I) or will interrupt the blood supply to the proximal fragment (type II). There were 8 cases of type II fracture.

3. Interruption of blood supply to the proximal fragment leads to temporary avascularity but not necessarily to aseptic necrosis.

4. Temporary avascularity of the proximal fragment delays union but does not prevent it, provided the wrist is adequately immobilized.

5. There were no known cases of nonunion or of aseptic necrosis in this series. Credit is given to the absolute fixation afforded by the plaster-of-

Para gauntlet which includes the base of the thumb

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HERMAPHRODITISM

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In order to clarify certain factors regarding hermaphroditism and its treatment, it seems fitting to begin the discussion with the history of a patient

A woman, aged 3 years, consulted Dr R G Worcester in April 1941, seeking advice about the abnormal development of her external genital organs. These are the notes of the history she gave to Dr Worcester.

When she was about 9 years of age she realized that she was different from other girls and withdrew somewhat into herself. She did not confide in her mother, and her parents had never indicated that they thought she was in any way abnormal. She had never been medically examined before. During her childhood she played with boys but states that this would have naturally occurred as no girls of her age were living close to her home. She played much sport at school and was quite good at hockey and swimming. When she was about 13 or 14 years, her voice broke and has since become deep like that of a man. At about 14 years she developed hairs on the face and chest, and for the past 3 or 4 years has found it necessary to shave her face daily. She has never developed any breasts nor has she ever menstruated. Her general stature has always been of the male type. She has been of an independent nature and went to work when she was about 17, the work being domestic service. She admires the male sex and seeks her friends among it, several attachments have been quite serious. There has never been any attempt at intercourse but she states that this has been so because of her fear of "others finding out what she was like," and in any case she thought it would not be possible. Recently there had been a little soreness of and some whitish discharge from the vulvar regions. Her main wishes were to continue living as a female and to have the abnormal swelling (very enlarged clitoris) removed.

On examination, the general body build was of the male type (Fig 1). The features of the face were harder than in the average female, the development of the beard could not be judged, because she could not be persuaded not to shave even for a few days. There was an amount of hair on chest, abdomen, arms, and legs, greater than in many men. The voice was quite deep, but there was no Adam's apple formation of the larynx. The region of the breasts was completely flat. Heart and lungs were normal. The abdomen was soft. No tumor was felt on palpation. There was a very tender mass in the left groin. The external genitalia presented the following appearance. There was a considerably enlarged clitoris (Fig 2), labia majora were present, labia minora hardly developed. The orifice of the urethra was at the basis of the clitoris. Posteriorly there was a "vaginal," consisting of a narrow canal which allowed a catheter to be passed in for about 1 centimeter. Much yellow discharge was seen in this region. X-ray pelvimetry (by Dr Colin Macdonald) showed an android type of inlet but otherwise all the measurements were within the range of a female pelvis. An estimate of the 17 ketosteroids gave a value within the normal female limits.

From the Department of Pathology, Women's Hospital Melbourne.

As the patient had most strongly expressed the wish that all possible male structures should be removed, an operation was performed on April 20, 1941. An incision was made over the swelling in the left groin, a gonad was found in the subcutaneous tissue superficial to the musculus obliquus externus. This was removed and the wound was closed. The abdomen was then entered through a midline incision and the other gonad was found near the internal ring at the right pelvic wall and removed. This proved to be the only structure in the pelvis between bladder and rectum; there was no trace of a uterus or appendages. As a third step the enlarged clitoris was resected.

The removed gonads appeared macroscopically to be typical testes. On microscopic examination structures very much like those of undescended testes were seen (Fig 3). The seminiferous tubules were well formed, they were usually lined by three or four layers of cells. These cells showed the usual differentiation, and a fair number of mitoses was present. Spermatogenesis, however, seemed to stop short of the formation of mature spermatozoa. The tubules were surrounded by very thick layers of connective tissue. The interstitial cells of Leydig were greatly increased in number, in one gonad there was a well defined nodule, measuring 4 millimeters in diameter, which consisted of rather immature interstitial cells.

The immediate postoperative course was uneventful. However, to the surprise of all concerned, she developed within some weeks all the symptoms of an artificial menopause. Treatment was for a time somewhat irregular and not quite successful because Dr Worcester had been called up for military service a few days after he had performed the operation. It was not until November, 1941, that carefully planned treatment was inaugurated. She received weekly injections of 40,000 units of estroform, after about 2 months the doses were gradually reduced to 10,000 units per week. This was continued until November 1942, i.e., injections were given for 12 months. Although a weekly injection of 10,000 units was just sufficient to keep her comfortable (one or two hot flushes used to occur on the last day of the week), a most remarkable transformation of the patient has occurred during the year. The hair growth on trunk and limbs has regressed to such an extent that it has become hardly noticeable. She reports also that the growth of the facial hair has regressed considerably, but self-consciousness still dictates daily shaving. The voice is now a somewhat broken alto. The patient has gained a good deal of weight, the deposition of fat tissue has occurred in a definite female pattern. Most remarkable, however, has been the development of her breasts. When first seen she had actually no more fat tissue in the region of the breasts than in the adjoining parts of the skin. About 3 months after the inauguration of the injections the areas just began to rise above the level of the surrounding skin. Twelve months later she has not very large, but very well developed breasts, as Figure 4 shows.

Of great interest are the psychological results of the treatment. She lost most of her self-consciousness. She took up swimming again, which she had not done for years, afraid of "being found out." It has been mentioned, that she had a "boy friend" even before operation. During the year this relationship deepened considerably, according to her statements she enjoyed his attentions very much more



Fig. 1. Patient shortly after operation, before commencement of hormonal treatment. Note general male habitus, no development of breasts.



Fig. 2. External genitalia before operation.

if I'm regretting only that she cannot be able to have children. In 1959 her condition has changed to an extra back, had not expected her rather differently commenced her treatment.

As stated in the opening paragraph of this paper the history of the patient has been given in some detail, first to give an account of the post-operative course and the social adjustment of the patient, considerations often omitted in discussions of similar condition and second, however for the even more important reason that anyone who peruses this history must arrive at the same conclusion as in this case, that either our management of the patient has been completely misdirected, that we had no right whatever to transform an undoubtedly male person into a female,

that it is our conception of hermaphroditism which is totally wrong. There cannot be any doubt about the choice between these two alternatives. When one realizes that she helped a sullen self-conscious freak (her own words) to become a happy married woman that we could have driven her to suicide had we told her to change her sex and start another life as a man, the only conclusion possible is that she has to revise our ideas about hermaphroditism.

When one tries to evaluate the literature one is very forcibly struck by the fact that the quantity and quality of papers dealing with this subject are inversely proportional to each other. This finds its explanation in a number of different factors. Many papers have been written at a time when essential details of anatomy, physiology, embryology and genetics are not known, cases have been observed and reported on by busy practitioners who had either not the time or not the opportunity to study the details meanwhile discovered but much of it is just due to careless-

and she became very fond of him. They began seriously to think of marriage. The main obstacle seemed to be the impossibility of intercourse.

As shortly before a member of our hospital staff, Dr. K. Campbell, had reported success with Steinmetz's method of creating an artificial vagina, I decided to make that an attempt at utilizing the existing rudimentary clitoris. Dilators of varying size had to be made from glass, as other material was not available. Through the intelligent co-operation of the patient a vagina was obtained which admitted two fingers to their entire length, in less than 6 months. Intercourse was then attempted and carried out to the satisfaction of both parties.

After 6 months' treatment by injections the medication was changed to stilbestrol by mouth, because the patient had taken up this work which prevented regular attendances at the hospital. Although she now takes the tablet only when she is troubled with hot flashes, the general physical and psychological feminization continues, but of course, at much slower rate than in the initial stages. She became married 18 months ago and is enjoying married

ness To give only one example In 1938 MacCahey devised a new classification of hermaphroditism For this purpose he selected from the easily available literature 67 cases as a basis for the four groups he proposed In 1942 another author comes along, adds a few cases from the literature and two of his own, and "brings thus the numbers up to date" As a matter of fact Neugebauer had published in 1908 a monograph based on the analysis of 1,262 from more than 2,400 cases reported up to this time In the face of this state of affairs no survey of the literature will be attempted Suffice to say that still the most widely used classification is based on Klebs' scheme, which comprised three groups (1) hermaphroditismus glandularis (true hermaphroditism), hermaphroditismus tubularis (pseudo-hermaphroditismus), (2) masculinus, and (3) femininus

Numerous subgroups have been suggested to these main groups Common, however, to all these classifications is the fact that, with the exception of true hermaphroditism (there are only about two dozen such occurrences), in all the others the anatomical structure of the gonads decides the sex of the cases "Case" is purposely used, because none of these classifications has attempted to take into consideration the personality of those concerned There is, however, no need, at least at this stage, to digress into this direction, it shall first be shown, that biological research over the past 20 or 30 years has led to results which are quite incompatible with the still widely prevailing ideas about hermaphroditism (hermaphroditism is used as a general term to include true as well as pseudo-hermaphroditism)

It is well known that a fertilized ovum has either a 1X (XY or XO) or a 2X (XX) constitution, and that accordingly a male or a female subject develops from it It is, however, not so well known to the medical profession, that every cell carries male (M) as well as female (F) factors, the F factor in the sex chromosome, the M factor in another chromosome pair The genetic formula for a male is therefore FMM , for a female $FFMM$ The usual clearcut sex determination results from a constant difference in the values of F and M in a given group, it can, however, be seen that the genetic sex differences are of quantitative rather than qualitative nature Goldschmidt has shown that it is possible to obtain conditions, in which this difference (epistasis in his terminology) is not sufficiently large To give an example If one sets the value of F arbitrarily equal to 40, that of M to 30, the above formulae would read



Fig 3 Histological structure of the gonad seminiferous tubules fairly well developed, but without spermatides, thick layers of connective tissue surrounding them Abundance of interstitial cells

$$FMM=40 \quad 60=\sigma \quad FFM=80 \quad 60=\varphi$$

If in another group of the same species F were equal to 60, and M to 45, one would get the same proportional relationship

$$F'M'M'=60 \quad 90=\sigma \quad F'F'M'M'=120 \quad 90=\varphi$$

By special crossbreeding one could arrive at an individual of the formula

$$F'MM=60 \quad 60=\sigma$$

or at another one

$$FFM'M'=80 \quad 75=\varphi$$

In such cases the epistasis would be too small for a definite sex determination and some degree of intersexuality (Goldschmidt) would result An individual with a genetic formula similar to the first is now called a male intersex, one with a formula similar to the second one a female intersex The term hermaphroditism has been abandoned, except for those species in which the individual has both testes and ovaries functioning and can act as a male or a female as well

That such deliberations are not idle speculation has been shown by Goldschmidt in very extensive experiments on the gypsy moth He could by crossbreeding of two different races of this species obtain, at will, practically all intermediate stages between a normal male and a normal female animal He could even show that complete sex reversal was possible, e g, that genetically 2X individuals could become perfect males (This can be proved, because "males by sex reversal" have, when mated to a normal female, only female offspring)



Fig. 4. Development of patient's breasts after months' hormonal treatment

In some detail Goldschmidt's conception is as follows. An intersex begins development according to its XX or XY constitution. Sooner or later depending on the epistasis, a turning into the opposite direction of development occurs, i.e. a first phase of female development is followed by a second phase of male development or vice versa. What degree of intersexuality results depends on the situation of the "turning point," i.e. on the time at which the second phase begins. A very early turning point may lead to complete sex reversal, a very late one can influence only organs and functions which have not yet become firmly established by this time. Goldschmidt's work has been confirmed by a number of investigators also for other animals.

The most important question now arises, whether these results can be applied to higher animals and to man, where for obvious reasons similar experiments are impracticable. There are two main difficulties which have to be overcome. First in lower animals differentiation of the primary as well as the secondary sex characters is, as far as we know, solely dependent on the chromosomal mechanism. In higher animals and man, however the sex hormones take over the directing and controlling functions at a comparatively early stage. Furthermore, in mammals and man the possibility of an influence of the maternal hormones on the fetus in utero will have to be

taken into consideration. Secondly while it seems quite possible that a human ovary may be transformed into a testis, it is much more unlikely if not impossible, for a human testis to become an ovary. (The ovary has to undergo a series of sex cords the second develops into the specific structures while the primary sex cords regress. Remnants of them, however persist and could provide the material for the subsequent development of testicular structures. In a developing testis however there is supposedly only one generation of sex cords, thus material for a subsequent development of an ovary would not be available. See however later!)

About these two points a controversy has developed between Goldschmidt and other biologists. Goldschmidt has, in one of his publications, shown in great detail how his conception of intersexuality can be applied to all known examples of such occurrences, whether in lower or higher animals or in man. A short summary of his ideas about human "hermaphroditism" is all that can be attempted. The so called male pseudohermaphrodites are female intersexes, i.e., they have genetically a XX constitution, but have undergone a varying degree of sex reversal. The so called true hermaphrodites are in principle nothing but the same. Only the transformation of ovaries into testes has not become complete. The so called female pseudohermaphrodites are, in his opinion, not intersexes at all, they are genetically normal females, they are cases of virilism due to hormonal disturbances during the fetal life comparable to those which follow the development of certain ovarian or adrenal tumors in later life.

Space does not allow to follow Goldschmidt's reasoning in detail; only one point may be somewhat elaborated: his rather surprising refusal to regard the female pseudohermaphrodites as intersexes. His explanations are: Male pseudohermaphroditism, i.e., female intersexuality in man is much more common than its opposite, and one would expect about equal numbers, were both conditions based on a similar chromosomal mechanism. Female pseudohermaphroditism, i.e. male intersexuality, is practically unknown in higher animals and there is, in his belief, the impossibility of a testis becoming an ovary.

This application of the results obtained in lower animals has been objected to by Witachi, although he himself came to rather similar conclusions in experiments on toads. He agreed with Goldschmidt on the interpretation of the female pseudohermaphrodites. Also his opinion they are cases of virilism in genetically normal females.

The male pseudohermaphrodites, however, originate according to him in genetic males. This opinion was mainly based on statistical evidence compiled by Pettersson and Bonnier, and Moebius when one adds up the numbers of males, hermaphrodites, and females in the family of cases of hermaphroditism it looks indeed, as if one had to count the hermaphrodites with the males to arrive at about even numbers of male and females. Witschi suggested as explanation of male pseudohermaphroditism that some genetic disturbance in $1X$ -fetuses makes them susceptible to the influence of the normal or even abnormal estrogenic hormones of the mother.

To account for the various manifestations of pseudohermaphroditism Witschi had to assume that a first period of male development is followed by a second period of feminization, and that this is often followed by a third period of remasculinization. In those cases of male pseudohermaphroditism which later on develop breasts and other female features, this third period is supposed not to occur because the maternal influence has been so strong as to prevent a later endocrine function of such testes.

There seems to be several debatable points in this theory: masculinization, feminization, remasculinization, this appears to be even more complicated than Goldschmidt's suggestions. The explanation of the failure of the third period to occur is not quite satisfactory, because one had to assume that the testis had lost the power to produce androgens, but could still produce estrogens. It is further noteworthy, that the psychological development, especially feelings toward the one or the other sex, are often in contrast to the most conspicuous physical characters (as in our case: very marked male habitus, but definitely female behavior). In view of the facts that normal individuals of both sexes produce male as well as female sex hormones, only one in greater quantity than the other, and that testis and ovary are the common, but not the only source of them, it seems to me that even if hormones had such influences as Witschi suggests, the proportion of their production and their effect would depend more on genetic conditions than on anatomical structures. In a recent paper written in collaboration with Mengert, however, Witschi comes to the conclusion that the male pseudohermaphroditism should be divided into two groups: one, for which his first theory applies, and another one the members of which are genetically females, which have undergone partial sex reversal. He includes in this group especially those intersexes, which have in spite of the presence of testes fully developed

secondary female sex characteristics. An important point in his deliberation is again the study of the family of the two cases on which his paper is based.

It is not possible for one who is not a trained biologist to decide whether the number of carefully analyzed families is great enough for such far-reaching conclusions, nor to pass judgment on the greater probability of either of these theories, but a most important conclusion can be drawn: Hermaphrodites are not, as we have been led to believe just males or females afflicted with a set of malformations, although they have a fundamental $1X$ or $2X$ constitution, there is a disturbance in the relationship of the F and M factors, either on a pure genetic basis (Goldschmidt) or a mixed genetic-hormonal one (Witschi). And that hermaphroditism is a deviation from the normal effects of the F and M factors, i.e., a state of intersexuality, is all that matters to the medical profession, not so much how it was brought about and whether it superimposed on an original $1X$ or $2X$ constitution.

One would have expected that these results of biological research would have made a profound impression on all subsequent medical writing. It is most astonishing that a study of the literature reveals that only very few serious attempts have been made to utilize these results from the medical point of view. Moszkowicz has tried in a number of papers to introduce Goldschmidt's work to the medical profession. He has in one of them pointed out that the position of even a rudimentary prostate is of great significance for the interpretation of doubtful cases. Finally, he published in 1936 a very comprehensive review (about 200 pages) of the whole problem, and in this he has actually gone a good deal further than Goldschmidt. He has incorporated a number of borderline conditions like hypospadias and even homosexuality, he regards female pseudohermaphroditism as male intersexuality for the reason that the embryological work of Gruenwald has shown that in contrast to the previous belief a developing testis has also secondary sex cords, which could provide material for a subsequent development of ovarian structures. He has actually drawn up a complete scheme for all possible stages of intersexuality. Even if one is doubtful whether this vast expansion of the original ideas were justified, as e.g., Goldschmidt does, one would at least expect that his papers would have become the basis for a fruitful discussion. Far from it. Also his work has had hardly any repercussions in the medical world. In 1937 H. H. Young published a book which is invaluable as a

documentary collection. I cases of hermaphroditism he even gives in an introductory chapter an account of Goldschmidt's work but when he proceeds to the description and evaluation of his material he follows along the old familiar lines. Some later writers began to use in their publications

intersex for pseudohermaphroditic but, fundamentally very little changed. Novak has attempted to introduce the new ideas into the American medical literature although, as he himself says in a somewhat sketchy way, again with very little success. Then there is Witachi and Mengert's paper already referred to in which Witachi comes closer to Goldschmidt's point of view and in which he suggests that the nonenvironmental homosexuals might well be sex reversed females, a suggestion which has already been made by Moszkowicz. McCabe's attempt of a new classification is of interest in so far as he abandons the use of the anatomical structure of the gonads as the main criterion of sex determination, but when he expresses the opinion that the cases with testes are male or female according to the presence of derivatives of the Wolffian or Müllerian ducts one cannot follow him any further. Although his suggestions were initiated by the feeling of dissatisfaction with the present state of affairs, they lead, I am afraid, not in the right direction and it would be regrettable if their acceptance would impede further progress which can be based only on the biological data.

The reasons why this paper has dealt to some length with the results of biological research remain these: first, a better acquaintance with these ideas will stimulate a more careful and better planned investigation of cases of hermaphroditism, the theory of Moszkowicz with regard to the significance of the prostate deserves special attention. Second, as soon as the evaluation of cases of hermaphroditism the supremacy of the anatomical structure of the gonads is definitely broken the way will be open for better understanding and more reasonable management of such cases. One aspect of the cases but the most important one of the patients has often been unduly neglected, that is the psychological one. Patients who come to seek medical advice are not cases with genetic or hormonal disturbances, they are human beings usually with quite

definite male or female behavior who are worried by some physical aberrations, sometimes however in great distress over the discrepancy in their development and their up-bringing. Wise surgeons have already in the past refrained from telling their patients what was the right thing to do, and have helped them to become as nearly

as possible what they wished to be. But in doing so they have often been troubled by their conscience by the feeling that they had really no right to do as they did. Often only half-hearted measures have been taken. It is hard to believe that one patient, described as a brilliant female was relieved of her urge toward her own (the male) sex by removal of the testes. Worst of all, plastic masculinizing operations have been done on children on the assumption that anyway most of the pseudohermaphrodites are male.¹⁴ How distressing have been the consequences of such operations, when at puberty female breasts developed and female behavior became apparent.

In possession of the new knowledge the surgeon will have a different approach to such patients. He will realize that their management should follow these lines. In patients in whom ovaries are present or when at least their presence is strongly suggested, it has first to be ascertained whether or not the symptoms of virilism are due to an ovarian or adrenal tumor. If such be found its removal is usually followed by a remarkable improvement. Menstruation and pregnancy may occur although some features as facial hair and deep voice may be slow in disappearing. If no such tumor is found, the condition might be due to hyperfunction of a not enlarged adrenal, or the patient might be a male intersex with a high degree of sex reversal.

In the first case very little can be done, in the second management will have to follow similar principles as in the opposite condition to be discussed now. All cases in which testes are present, either alone or in combination with ovaries, should be regarded as intersexes. Whether they are based on male or a female genetic formula is a matter of great scientific interest but of very little practical importance. Sex reversal in such intersexes often affects the physical and psychological characteristics to quite different degrees and for the proper management it is only the psychological ones that count. If careful psychological examination reveals definite male or female behavior the surgeon can, with a clear conscience, use his skill in correcting physical aberrations. If the psychological attitude is not so clear a course which causes the least disturbance and promises the greatest improvement of the pre-existing conditions will have to be followed. But in any case the anatomical structure of the gonads should be the least worrying factor. It has even become questionable whether in cases with definite female behavior the testes should be removed in every instance.

It has been shown that such operations often have the same effect as castration of healthy

ACUTE CHOLECYSTITIS

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FOR many years, and particularly for the past 5, medical literature has been replete with discussions, discourses, and statistical reviews representing actually thousands of patients operated upon for biliary tract disease. Lately the ever present argument occupies the front of the stage as to whether early, delayed, or late operation on the acute cholecystitis case gives the best mortality and morbidity results. Cholecystitis actually or apparently seems on the increase in the United States. At the gastrointestinal clinic in the Hospital of the University of Pennsylvania, Dr. T. G. Miller has found that biliary disease is responsible for 40 per cent of the complaints treated there. Perusal of the figures from dozens of clinics widely scattered over this country shows that approximately 20 per cent of all biliary cases must be classed as of the acute type of cholecystitis. We believe that the best results are obtained when surgery is undertaken in the early (hours) obstructive stages before infection *per se* has resulted in suppuration. An attempt will be made to present in compact form the accumulated statistics from the numerous published articles and from these results and our own experience to try to prove what factors are chiefly concerned in the mortality and morbidity of this disease.

For simplicity and in order to save printing the bibliography of the reported statistics with few exceptions will be omitted and the various references tabulated by serial numbers only.

AGE OF THE PATIENT

All writers on the subject are in accord in stating that the older the patient the higher the mortality and morbidity. It can be safely stated that 15 per cent of the people in the United States suffer from biliary disease, and that this figure increases to 30 per cent after 45 years of age. Crump states that at the postmortem table stones were found in 33 per cent and diseased gall bladders 60 per cent of subjects. In fact a careful analysis of 1,060 reported cases shows that the mortality after 60 years is 8 to 10 times the mortality before that period. The reasons for this are evident.

There is more serious biliary damage because of the long period of the disease existing before the acute attack precipitating operation. Often pancreatitis and hepatitis together with cardiac and renal disease result in more frequent and even fatal postoperative complications. Then too, the diagnosis is often more difficult to make because as is well known the aged patient does not show the same amount of rigidity, pulse, or temperature reactions as occur earlier in life. Furthermore the leukocytic reaction is less marked, and the indifference and lethargy minimize pain and tender ness in these elderly patients.

It is interesting to note however that in many series the mortality in the age period before 30 years is higher than it is in the period between 30 and 50 years. This is probably accounted for by the fact that the old, large fat and forty attracts our attention the most and so results in delayed diagnosis in the younger patients, with resultant catastrophes. The authors have operated upon several patients in the teens with acute disease. One a 7 year old boy with gangrenous cholecystitis.

DURATION OF THE DISEASE

Graham aptly illustrates the danger of procrastination by citing operative mortality figures for cholecystectomy. If done after 2 attacks it is 2 to 3 per cent, after 3 or more attacks 8 to 9 per cent, in the presence of jaundice 10 to 12 per cent, and with pancreatitis it is 50 per cent. Miller of the Massachusetts General Hospital noted that in the fatal cases the average period from the onset of symptoms to operation was 15 days, while in those who recovered it was but 8.3 days. Zimlinger noted that with delayed operation one-third of the patients recovered, one third did not change and one third became definitely worse. The above data should favor early (hours) operation. Comparison of Tables I and II shows that the 48 hour group has the lower mortality. The 20 series contain only cases of acute cholecystitis.

SEX

At the Union Memorial Hospital in Baltimore the mortality in men was 5 per cent and in women it was 6 per cent. In our series the only deaths were in males operated upon with suspicion of acute appendicitis. Other clinics show

From Surgical Section A of the Hospital of the University of Pennsylvania.

Read before the Eighth Annual Postgraduate Institute of The Philadelphia County Medical Society, May 14, 1924.

TABLE I —REPORTED STATISTICS MORTALITIES
— CHOLECYSTECTOMIES PREDOMINATING
(4-1) ALL CASES REGARDLESS OF DURATION

Series	No cases	Mortality per cent
1	159	8.3
2	44	4.5
3	129	16.3
4	320*	5.3
5	197	5
6	150	6.2
7	300	10
8	107	9.3
9	153	5.8
10	140	8.6

*No cholecystectomies in this series

These figures were obtained from the reports of 20 clinics appearing in the literature within the last 5 years. They represent the run of the mill with regard to the duration of the attack which to some extent may account for wide difference in mortality figures. These are all acute cases

similar results. Two reasons present themselves to us to account for this difference—first, the fair, fat, flabby, fertile, flatulent female of forty (the seven f's, aptly expressed by Owen of Philadelphia) with a pain in the upper abdomen immediately suggests gall-bladder disease as the most likely diagnosis, whereas in the average male, a peptic ulcer or coronary disease are first impressions, thus resulting in delays incident to the establishing of a definite diagnosis. The second reason is that most often in the female the distended viscus points toward the umbilicus whereas in the male it very often points out toward the flank. The complaint, therefore, is frequently erroneously diagnosed as an acute appendicitis, an enlarged tender kidney, or a lesion in the hepatic flexure.

DURATION OF THE ACUTE ATTACK

The time that elapses between the onset of symptoms and surgical intervention has a definite bearing on the mortality. Hedy shows in 3,986 cases that the safest time for operation is between 6 and 24 hours. Lanahan in 140 cases, however, has the highest mortality in the 24 hour or emergency group. Several other men report a relatively high figure in this group. A possible explanation of this occurrence may be that the emergency operations are often done by the younger, less experienced surgeons, at night, with hurried preparation, the least experienced anesthetist, and an interne (maybe, in these days, a very green one) as assistant, and a pupil nurse as suture helper, likewise green and frightened. We all have seen such setups more than once in many hospitals.

American surgeons who have ardently supported early operation are Alexander, Estes, Eliason, Finney, Graham (H. T.), Heuer, Judd

TABLE II —REPORTED STATISTICS MORTALITIES
— CHOLECYSTECTOMIES PREDOMINATING
(12-1)*—DURATION LIMITED TO 48 HOURS

Series	No cases	Mortality per cent
11	20	5
12	50	4
13	7	0
14	19	5.2
15	6	0
16	51	3.9
17	12	0

*Note the effect of early operation on the ratio 12 cholecystectomies to 1 cholecystostomy

These figures also were obtained as were those in Table I but represent only those patients operated upon within the first 48 hours of the illness. Compare the difference in the number of cases in the two tables.

and Phillips, Lund, Mentzer, Miller, Owings, Pratt, Royster, Stone, and Zinninger. Others equally well known and experienced recommend delayed operation—such men are Bass, Behrend, Bruggeman, Branch, Deaver, Flint, Graham (F. A.), Lewis, and Lahev.

When such an array of authorities disagree there must be something in their statistics that does not meet the eye. Do they all use the term "early" meaning hours only or do they mean 2 or 3 days? Have the early mortalities been in their hands or in the hands of young assistants? In the early fatalities have the patients been opened with a mistaken diagnosis of appendicitis or a salpingitis and a second incision or supplementary anesthesia been necessitated? It would seem in all fairness that such data should be available to justify fatalities that should not occur. For, it is a strange thing that although surgeons are almost universally agreed that acute appendicitis should be treated surgically as an emergency (hours, not days), yet in the case of acute cholecystitis, in which it is generally agreed that one cannot prognosticate the severity of the pathological condition, they wait an indefinite time before undertaking surgery. This position seems doubly untenable when some writers report perforations as having occurred in 24 hours. McNealy reported 3 such cases. It would appear that these time periods must have been estimated from the time of admission to the hospital and not from the onset of the disease—another example of the uncertainty of statistical interpretation. It is true that the average time elapsing before perforation is about 6 or 7 days, with an average mortality for all reported perforations approximating 45 per cent. In 35,000 cases mentioned by Heuer, 20 per cent went to perforation with a mortality of 10 per cent. Why wait for such catastrophes? The variation between 45 per cent and 10 per cent is possibly accounted for by the time lag before

TABLE III. — CHOLECYSTOSTOMIES PREDOMINATING (9-4) ALL CASES REGARDLESS OF DURATION

Cases	No. cases	Mortality per cent
8	44	
9	35	5

* (personal series)

These are the only two series reported in which cholecystostomy predominated.

operation and the type operation whether a cholecystectomy or a cholecystostomy was performed. Eliazon and MacLaughlin reported 9 perforations with 1 death. This death followed a cholecystectomy the 8 survivors had cholecystostomies performed—a significant factor as the surgeons with the high mortalities had practiced cholecystectomy uniformly (Table II)

CULTURES

Negative cultures from the gall bladder were noted in approximately 50 per cent of collected data and would seem to indicate that obstruction and possible chemical reaction are the important factors in the early stages (12-48 hours) of so called acute cholecystitis. This is borne out by our pathologist who states that but for the clinical picture of acute infection he could not truthfully describe a great proportion of these specimens as being the seat of an acute infection but would rather favor that of a vascular obstruction diagnosis. Evidences of true acute inflammation histologically are difficult to find in a fibrosed, thickened gall-bladder wall. The commonest organism was the colon bacillus (5 per cent of infected cases). The combined data from Finsterer Smith, and Kruger with 317 cases mention only 1 patient as dying from peritonitis. The data presented therefore should lead one to discount the importance of the infectious factor as contraindication to early operation as has been held by several authors.

Confusion has arisen due to the failure of many advocates of early surgery to state clearly in their account.

1. Whether immediate operation means an emergency procedure done within 1 hour or of the onset of the illness, or after the patient's admission to the hospital, or one done after complete studies can be made to assess the patient's condition and time allowed for the required pre-operative preparations to be carried out, regardless of the duration of the acute attack.

Whether cholecystectomy is done as a routine procedure or the operation is adapted to the findings.

TABLE IV. — REPORTED STATISTICS — FUNCTION AFTER CHOLECYSTOSTOMY

Minor feml von Stock	Normal	Per cent
	Normal	60
	Normal	61
	Normal	78

3. Whether the incidence of the late complications of biliary fistula and strictures of the ducts following the removal of acutely inflamed edematous gall bladders has increased therefrom.

PRELIMINARY TREATMENT

In cases with a positive or proved diagnosis seen during the first few hours of an attack, morphia hypodermically and atropine should be given at once and everything withheld by mouth. Fluid, preferably glucose 5 per cent in salt solution, and water is given by rectoclysis. Operation is undertaken as soon as the necessary general medical survey can be carried out, bearing in mind the frequent coexistence of diabetes and cardiac disease with biliary tract disease. At this stage the absence of edema, as a rule, permits the ideal cholecystectomy to be performed. Those patients, however who have been ill 24 to 36 hours without adequate treatment are also best managed by this same regimen of morphia rectoclysis, and starvation for 12 to 18 hours. If after this period any one symptom fails to subside, operation is done. Similarly patients admitted after 24 or more hours who are still ill despite this proper treatment, should have prompt operation. It has been our experience that acute obstructive gallbladder disease of 3 or more days duration as a rule will not subside completely under any treatment except surgery, hence further delay is dangerous and useless. The procedure may be either cholecystostomy or cholecystectomy depending upon the local conditions which do not permit safe surgery such as the absence of induration or edema around the ducts, obscured anatomy, pancreatitis, jaundice perforation, etc.

The pathological state of the gall bladder cannot be safely estimated by any physical or laboratory tests—hence the danger of delay. Not infrequently the problem will arise of persuading a patient to have the operation when he or she seems to have recovered. Such patients are courted by certain trouble and the necessity for operation should be insisted upon at the first evidence of suggestive symptoms. Here the persuasive aid of the attending physician is invaluable.

Before the actual surgical treatment is determined it might be well to pause for a moment and discuss the subject in its broadest sense. We most

remember that our first aim is to save life and our next aim is to restore health. When we read the statistics in the literature and see their enormous variation, we must appreciate the fact that the mortality and morbidity figures will be much higher among average surgeons than those published by the surgeons with a much greater experience. Perhaps it would be better should a higher percentage of cholecystostomies be performed and a more frequent use of drainage in both cholecystostomies and cholecystectomies be instituted. In the ultimate analysis the patient who can't reach a large city clinic is interested in what chance he or she has with their local surgeon. For all to attempt cholecystectomies that may result in disaster is not justified (Tables III and IV).

PERSONAL EXPERIENCE

In determining the operation to be done, the crux of this problem lies in the recognition not only of the fact that acute cholecystitis demands early surgical intervention but that the operation must be suited to the existing conditions. Accordingly the procedure which may be ideal from the standpoint of ultimate morbidity may have to be modified for the sake of immediate mortality. Cholecystectomy is a better operation than cholecystostomy but the latter may frequently be safer and more prudent. The rule must be observed absolutely that cholecystectomy should never be done unless the relationships of the hepatic, cystic, and common duct, and the cystic artery can be clearly visualized by the surgeon. Granting that in all cases cholecystectomy is more satisfactory from the standpoint of ultimate results, the indications for cholecystostomy may be stated as follows: (1) when the condition of the local tissues militates against safe removal of the gall bladder, (2) when the physical difficulties of obesity, uneven anesthesia, poor illumination, or inadequate assistance make proper exposure impossible, (3) when serious local complications such as jaundice, pancreatitis, or cancer call for drainage only, (4) when age or serious renal, cardiovascular, or pulmonary complications indicate that surgical intervention should be simple and expeditious. The safety of the patient is greatly enhanced if the surgeon will recognize not only his own limitations but also those of his patient, and stop with a cholecystostomy rather than attempt too much at one operation. Time and our patience will not permit the hundreds of statistics which prove that cholecystostomy has a higher mortality than does cholecystectomy. We must bear in mind that a simple drainage of an acute cholecystitis would not have any higher mor-

talidity, if as high as that of cholecystectomy, except for the serious complications, already present, which would result just as fatally and be charged to a cholecystectomy, if such were done.

OPERATIVE TECHNIQUE

Cholecystostomy Infiltration anesthesia with procaine may be used in bad risk patients on whom the simplest form of operation is to be done. Whenever circumstances permit, spinal or inhalation anesthesia is preferable since it gives more adequate exposure and enables the surgeon to do a more satisfactory operation.

As to the incision, our preference is for the subcostal approach, the line of skin incision being one finger breadth below the costal margin and parallel with it. In the unruptured case when cholecystectomy is deemed advisable, the field is cofferdammed and a gauze pack is also placed on top of the liver edge beneath the costal arch. This incision exposes a minimum of small gut and hence minimizes the danger of spread of infection. The gall bladder is opened with the sharp Ferguson drainage suction tip and so emptied. It is now opened wider and emptied of stones and inspected with the scope. The senior author and L. K. Ferguson have devised a cholecystoscope which is on the order of a short sigmoidoscope and carries a light at the tip and suction channel. This is a great aid in visualizing the inaccessible portions of the gall bladder. This has enabled us to recover stones in 15 per cent of cases in which our fingers and scoops have missed them. When all stones have been removed, clear bile may enter the gall bladder although often the edema about the cystic duct prevents its immediate appearance. Cholecystostomy, although a stop gap procedure in many instances, has resulted in cures in approximately 84 per cent of the cases upon whom we have employed it. The use of the cholecystoscope may be a factor in our results immediately as well as in reduction of future recurrences since stones are rarely left behind by this method.

In addition to tube drainage into a bottle, a Penrose cigarette drain is placed down along the bladder in every case. The figures in our series would seem to justify this procedure. Decompression drainage was carried out with little success and bile restored to the stomach by tube or lyophilization if necessary. It is our impression, although not checked, that the wounds in these cases compare favorably with the cholecystectomies as far as herniation occurrence.

Cholecystectomy From the technical standpoint considerable muscular relaxation is essen-

tial for proper exposure. Nitrous oxide and oxygen alone will not provide this with safety even with an expert anesthetist. Cyclopropane or ethylene may do so. Either by open drop or in combination with gaseous agents is the most dependable and satisfactory of the inhalation methods. Due to the characteristic short necked, wide chested configuration of many patients with gall-bladder disease, the endotracheal technique of administration of inhalation agents is often of great aid in insuring an unobstructed airway and controlling the depth of anesthesia. Local infiltration with novocain has been espoused by some enthusiasts but requires considerable skill and much patience. Spinal anesthesia in our hands is being used more and more since the advent of the physician anesthetist. When combined with heavy preoperative medication or intravenous pentothal it is very satisfactory.

The same incision is used for cholecystectomy as for cholecystostomy. There is more than one way of removing a gall bladder but we prefer first to identify the cystic duct and its relation to the hepatic and common ducts, ligate it and the cystic artery and then proceed with the dissection of the gall bladder from its bed, beginning at the ampulla. This enables the operator to visualize these structures in a dry field and permits the accomplishment of the difficult and precarious portion of the operation with the best visibility. Deaver has pointed out that the textbook description of the relations of the biliary ducts obtains in only 53 per cent of the cases. In 26 per cent the hepatic and cystic duct run parallel to one another and the former may be injured if care is not exercised. Accessory ducts are present in 8.7 per cent, the most common anomaly being an accessory right hepatic duct arising from the cystic. Ligation of this may be fatal and leaving it wounded and open will result in a biliary fistula. It is helpful to remember that the veins in the plexus over the cystic duct lie parallel with it whereas over the common duct they form a network. If exposure is inadequate at this point it is sometimes helpful to aid in the rotation of the liver by placing gauze pack over its dome. By means of a ligature corner or a curved hemostat, two strands of No. 1 chromic catgut are passed around the duct, and the latter is doubly ligated close to its juncture with the common hepatic duct. In the presence of much edema the tying of the vessels should be done slowly and snugly and a final inspection should be made to be sure that the artery is still closed. Ofttimes bleeding is seen through the ligature as it presses the edema out of the ligated tissue. Routinely a soft clear

ette drain is placed in the fossa above the duodenum and brought out on the lateral angle of the wound. We have never had cause to regret this procedure. Not infrequently bile stained drainage material for several days makes the surgeon thankful that the wound was not tightly closed. Partial cholecystectomy has not been necessary with us as yet. A cholecystostomy has been deemed preferable. Occasionally a stone has been left in an inaccessible position in a patient desperately ill for later removal if necessary.

RESUME OF CASES

In our series of 135 consecutive cases of acute cholecystitis classed as such by the pathologist, the procedures here outlined were practiced uniformly with the following results:

Mortality. There were but 2 deaths—1.5 per cent mortality in the series. Interesting facts about the deaths: both were men, one was operated upon under spinal anesthesia 2 hours after admission, under the mistaken diagnosis of acute appendicitis. Through a second incision, a cholecystostomy was performed. The patient died on the 4th postoperative day with acute congestive heart failure and bronchopneumonia. The other death was of a 54 year old man, sick 2 weeks, operated under spinal anesthesia 48 hours after admission, and a cholecystostomy was performed. He was a diabetic with rheumatic and arteriosclerotic heart disease with aricular fibrillation. He died on the 9th postoperative day from a mesenteric thrombosis.

Age group. In the first group between 10 and 30 years, there were 3 cases. In the second group between 30 and 50 years, there were 48 cases. In the third group between 50 and 80 years there were 37 cases and 1 case was over 80 years of age.

Clinical course. In 21 per cent of the series the leukocyte count was normal. In 3 per cent temperatures were normal. In 30 per cent there was no palpable mass. In 8 per cent there was no suggestive previous history and in 4 per cent no local tenderness was elicited.

Hospitalization delay. In 20 per cent operation was carried out within 24 hours. In 76 per cent operation was carried out within 48 hours. In 90 per cent operation was carried out within 1 week.

Pathological condition. Of the 35 cases of acute cholecystitis there were with perforation 7 with no deaths with empyema 38 with death and with gangrene 46 with 1 death.

Perforation was found in 17 cases with a localized pericystic abscess. In this group 6 patients had the acute attack less than 1 week before operation and in 4 gall bladder perforated in less than

base of the neck without displacement, these appliances were fairly successful. However, the confining effects of such splints too often produced pressure ulcers, muscular weakness, and residual joint stiffness which interfered with complete recovery. Moreover, later observations have shown that such so called "conservative treatment" is attended by a high mortality which neutralizes any advantages of the closed methods of treatment.

The utilization of traction to immobilize trochanteric fractures is subject to many of the same criticisms. Gibson's well-leg traction, Gordon Buck's adhesive traction, the Maxwell-Ruth combined traction, Russell's balanced traction, Roger Anderson's and Carl Jones' well-leg traction likewise confine the patients to such an extent that pressure ulcers are likely to form and stiffness of joints frequently results. These complications delay recovery and the final condition of the patients is too often unsatisfactory.

Internal fixation of trochanteric fractures has reached a stage of development where it promises the most satisfactory effects of any of the established forms of treatment. Screws, nails, and pins which were suitable for fractures of the femoral neck have been utilized in trochanteric fractures but they were found to be suitable only in those cases which were not comminuted or in which the lateral cortex of the trochanter was intact. To increase their usefulness, plates have been attached which anchor the nails to the femoral shaft below the site of the fracture. More recently, one piece angle nails have been evolved by Jewett, Neufeld, and Moore which are universally applicable to all types of trochanteric fractures whether simple, comminuted, or spiral.

With modern anesthetics of less shocking action and intravenous fluids which are free of untoward reactions, operations upon very old patients can be undertaken with much more

confidence than in former years. Moreover, since it has been found that "conservative treatment" is attended with high mortality, it is preferable to consider internal fixation of trochanteric fractures unless the patients are so frail and feeble that there is no hope of survival. Also, with internal fixation, pain is reduced to the lowest level so that depressing narcotics are seldom necessary and patients can be assured of more nearly normal hip function afterward. The arguments against internal fixation are that elderly patients are poor operative risks and that they are already suffering from the shock of a severe accident. Nevertheless, this can be countered by the fact that patients whose fractures are immobilized with internal fixation suffer less pain, they are more likely to survive, and they are left with less disability at the end of treatment.

WALTER G. STUCK

POSTMORTEM EXAMINATIONS OF MILITARY PERSONNEL

WE, as physicians, are particularly concerned in these days with the welfare of the individuals in the military forces of this country. We feel fairly certain that no measure is being overlooked which will help to prevent the occurrence of disease or will hasten its relief if it once strikes. Wounds are being treated more promptly and with better success than ever before, and the death rate from the afflictions of war, considering all the hazards which surround modern warfare, is astonishingly low.

However, some must and will die and our concern about these does not end with their death. It is a debt to those still living, as well as to generations still unborn, that the circumstances surrounding their death and the conditions which are revealed in examinations after death should be recorded in as carefully detailed a manner as is possible under the cir-

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THE TREATMENT OF INTER- TROCHANTERIC FRACTURES

FRACTURES of the hip which are common accidents in the aged cause much pain and disability and frequently lead to hypostatic pneumonia and death. With the development of various hip nails and pins and the improvements in their use the worst of these complications have been materially reduced. Nevertheless, the great amount of attention which has been directed to the operative treatment of hip fractures in recent years has been concerned mainly with those in the neck of the femur. The equally common fractures at the base of the neck or in the region of the trochanters have received less attention because they were believed to be less serious and less likely to be followed by nonunion and deformity. This conventional view has been disproved by recent more careful studies of the problem.

Trochanteric fractures occur in older patients than fractures of the femoral neck and

since they are caused by more severe injuries, they are followed by a higher death rate. In several statistical studies which have been reported in later years it has been found that trochanteric fractures occur almost as often as fractures of the femoral neck and that they affect men more often than women. Also the right hip is the one principally involved.

A complete classification of trochanteric fractures is difficult since they are so varied in type and location. They may take the form of a simple crack across the base of the femoral neck, a comminuted fracture from the greater trochanter to the lesser trochanter ("intertrochanteric"), a fracture across the shaft between the trochanters ("peritrochanteric") or in the region of the shaft below the lesser trochanter ("subtrochanteric"). It is easy to see, therefore, how diverse the therapeutic problems may be depending upon the type and location of the fracture.

The treatment of trochanteric fractures is mainly directed toward the alleviation of pain and prevention of deformity since nonunion does not occur as it so often does in fractures of the femoral neck. The blood supply to the trochanteric region is entirely adequate to overcome the damage resulting from a fracture whereas in the femoral neck the blood supply is precarious and fractures in this location are often followed by nonunion or aseptic necrosis of the head of the femur.

The original plan of treatment of all hip fractures involved simple immobilization in external splints. The first to recommend this method was Ambrose Paré and his successors include Hodgen of St. Louis, John Ridlon, Nicholas Senn, D. P. D. Wilkie and finally Royal Whitman. For simple fractures at the

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

NOT a textbook, but a monograph, Dr Goodall's *A Study of Endometriosis, Endocervicosis, and Peritoneo-ovarian Sclerosis*¹ is therefore to be considered apart from the usual run of textbooks which are designed for students or general physicians. It presupposes a considerable gynecological experience and familiarity with both pathology and physiology.

We are glad to welcome a careful review of an important gynecological disease, and wish there were more such works. The practice of writing and publishing such monographs is not as common in this country as it is in France, where theses on various subjects are part of the required training for certain medical degrees. The reviewer has found these theses an invaluable source of knowledge in looking up particular gynecological subjects. For this reason, we welcome Dr Goodall's study.

Dr Goodall's monograph, however, differs from these foreign theses in that his is a presentation of his personal views and not an exposition of the known information on endometriosis. For that, it cannot be criticized, even though one may not agree with all of the author's views. We think it would have added greatly to its value and permanence, as a record, if it had presented a broader view of the subject.

Since it is a dissertation primarily on the pathology and etiology of endometriosis, the clinical features are more or less secondary. In the brief clinical sections, however, the author concentrates his wide practical experience. These sections would be of great value to all physicians, especially those who see many female patients.

We regret the absence of a bibliography. That is almost a basic requirement for a monograph, and we wonder why it was not included.

When viewed as a monograph of the author's personal views, this work can be appreciated as a contribution of great worth, based on a wide clinical and scientific experience. LAWRENCE WHARTON

THE volume of 128 small pages, *War Injuries of the Chest*² by Davies and Coope, is strongly recommended as a practical guide in the management of traumatic thoracic injuries. Although the subject could not be completely covered in detail in such a small volume, a surprising amount of useful,

specifically detailed instruction is given. Emphasis has been placed upon the fundamental importance of correction of derangements in thoracic physiology. In the words of the authors, "The physiological conditions of the chest and of the heart and lungs so intimately determine the very existence of the patient that the right application of the principles which follow from them is vital, not only for ultimate recovery but even more so for the immediate saving of life."

The two principal authors and the seven collaborators have presumably based their teaching upon first-hand experience with war casualties in England. Mr Davies is well known in America as a pioneer in modern thoracic surgery and is the author of a number of books on thoracic surgery. Doctor Coope is the physician to two important Liverpool chest hospitals. The collaborators in the preparation of this book include four thoracic surgeons, two anesthesiologists, and a pathologist.

In such a relatively young and developing specialty as thoracic surgery, differences of opinion between even experienced surgeons are inevitable. This reviewer happens to differ with the authors' preference for intercostal catheter drainage for pleural fluid collections instead of a partial rib resection for the airtight introduction of a tube that is sufficiently large not to become occluded by debris. He is also opposed to the partial replacement by air of pus aspirated from a total empyema, since the air rises to the top of the pleural cavity and prevents the rapid expansion of the upper lung. The same objection applies to the partial replacement by air of blood aspirated from a hemothorax, should the hemothorax be infected, or later become infected. The substitution of air for blood is, of course, necessary if the hydrostatic pressure of the blood is causing cardiocirculatory or respiratory decomposition and if present or recent bleeding from a wound of the lung requires continuing pulmonary collapse. The English authors' fear of ether anesthesia in the presence of pulmonary infection and their opinion that "cyclopropane is the best anesthetic for all operations involving the thorax" are not shared by the anesthesiologists in the principal thoracic surgery clinics in this country.

The personal disagreement about a very few things expressed in the last paragraph is trivial when weighed against the overwhelming rightness of the teachings of this book, which should be thoroughly studied by every surgeon who cares for war injuries, or civilian traumatic injuries, of the chest.

JOHN ALEXANDER

¹A STUDY OF ENDOMETRIOSIS, ENDOSALPINGIOSIS, ENDOCERVICOSIS AND PERITONEO-OVARIAN SCLEROSIS. A CLINICAL AND PATHOLOGIC STUDY. By James Robert Goodall, O.B.E., B.A., M.D., C.M., D.Sc., F.I.C.S. (Hon.) F.R.C.O.G. Philadelphia, London and Montreal: J. B. Lippincott Co. 1943.
²WAR INJURIES OF THE CHEST. By H. Morrison Davies, M.Ch., F.R.C.S. and Robert Coope, M.D., F.R.C.P. Edinburgh: E. and S. Livingstone 1942.

THE book entitled *Pictorial Handbook of Fractures* by T. Coleman has served its purpose very well and fulfills the title of the handbook.

The discussion is kept simple without any needless theorizing, and only well grounded accepted principles are presented with excellent illustration. The drawings by Dr Harold Laufma bring out all the desired details which might be confusing from the written matter in the discussion. Both the non-operative and operative treatment of the fractures of the body are discussed, and with very few exceptions the textbook follows good orthodox teaching.

It will be of considerable value to both medical students and the general practitioner, who has had no special training in this particular field.

CARLO S. SCORIO.

A TIMELY addition to the literature of nursing is *Nurses in Action* which may be characterized as a seven volume library dealing with the various though related aspects of my life. The introduction from the pen of Lieutenant Colonel L. L. Gardner M.C., A.U.S. says of Colonel Fisk:

She speaks with the conviction and intimacy of lifetime of Army service, and her words are lighted with all the special knowledge and theory which derive directly from her distinguished position as Superintendent of the Army Nurse Corps on duty in the office of the Surgeon General of the War Department, Washington.

The book opens with a lively description of the nursing scene as it is enacted today in the main parts of the world where Army nurses are found. The picture has two distinct appeals: vividness which cannot but stir the enthusiasm of the new recruit and wealth of anecdotes, garbed though they are in modern dress, which will bring both tears and smiles to the veterans of World War I.

The history of the Army Nurse Corps, which follows, traces in interesting fashion the development of the Corps from its earliest days up to the present.

The following chapters, *Becoming an Army Nurse*, *Nurses at Work* and *Nurses in Action*, describe the life of an Army nurse its joys and its sorrows, its duties and its privileges offering authoritative answers to many of the questions which beset the director of nursing today. Throughout, the ideals of service, teamwork and loyalty to great tradition are paramount.

The concluding chapter *Other Government Services* enhances the usefulness of the book and will be welcomed by teachers of nursing history and professional adjustments. *Nurses in Action* should prove a valuable addition to the nursing school library.

ELIZABETH W. ODELL.

PICTORIAL HANDBOOK OF FRACTURES. By T. Coleman. M.D., F.C.S. and F.R.C.S. (Ed.) London, M.D. Chicago: The Year Book Publishers, Inc. 1934.

NURSES IN ACTION. THE STORY OF THE ARMY NURSE CORPS. By L. L. Gardner, M.C., A.U.S. and J. F. Fisk, M.D. (Ed.) New York: McGraw-Hill Book Company, Inc. 1934.

THE small, 87 page text, *Aids to Surgical Anatomy* will quite certainly be found of use to students during their senior year and when they are preparing for their final examinations. The sections on the head and neck are covered amazingly well in this second edition which new material has been added. The surgical significance of anatomy is also adequately considered for a text so small. If there were more than the twenty-six illustrations, the book would have greater teaching value. This abbreviated *Surgical Anatomy* with its wealth of information well merit study by surgical residents beginning their careers.

Samuel J. Footman.

THE revised and enlarged edition of Cole and Puestow's *First Aid* fulfills real need for authoritative information about first aid in civilian as well as in military practice. The new chapters on miscellaneous conditions requiring first aid and the sections on medical emergencies, poisons, and foot lesions are particularly valuable just at this time.

The authors present the latest information regarding the treatment of wounds, burns, and shock, and prevent the problems of abdominal pain and abdominal injuries in an instructive manner. All of the illustrations are well chosen and carefully designed to supplement the text. The authors emphasize the importance of having thoroughly trained first aid personnel if the greatest good is to be accomplished.

In addition to the two authors, an entire membership of the teaching staff of the University of Illinois College of Medicine have contributed chapters to this volume. All medical student should be encouraged to master the fundamental principles of medical and surgical practice as they are set forth by these teachers.

This volume is highly recommended to civilian and military doctors, nurses, and medical students and to those laymen who are charged with the responsibility of first aid instruction and care in industrial and civilian defense work.

LOUIS G. HERRMAN.

THERE can be no question about the value of Dr. Gelet's monograph on *Ovarian Tumors*. It is very well illustrated. His opinions, gleaned from his vast experience are of great help in the understanding of ovarian tumors. The chapters on embryology, anatomy and physiology are important and the presentation is clear and concise. The book is full of foreign references but there is definite dearth of references to English and American writers.

There is nothing of importance left out of this book. It could be wished that speculation as to the origin, female sex hormones and ketosteroids in male tumors and estrin and female sex hormones in female tumors had been included. Dr. Gelet's ex-

AMERICAN HANDBOOK OF SURGERY. By J. S. Jackson, M.D. M.B. F.R.C.S. (Ed.) Baltimore: The Williams & Wilkins Co. 1934.
NEW ARMY SURGEON ON MEDICAL. By L. L. Gardner, M.C., A.U.S. and J. F. Fisk, M.D. (Ed.) New York: McGraw-Hill Book Company, Inc. 1934.
NEW ARMY SURGEON ON MEDICAL. By L. L. Gardner, M.C., A.U.S. and J. F. Fisk, M.D. (Ed.) New York: McGraw-Hill Book Company, Inc. 1934.

perience with the comas alone might well open the way to research into the various hormonal titrations in such conditions.

The great diversity of ovarian tumors and cysts will always prove a beautiful hunting ground for the gynecologist and especially for those interested in pathology and endocrinology. This book goes a long way to being the perfect reference book and should be near the clinician's desk and the pathologist's bench.

JOE VINCENT MILES

THE concise monograph by Eli Moschowitz¹ on the subject of vascular sclerosis, reviews the important clinical, investigative, and pathological work that has been done on arteriosclerosis. It is written considerably from the standpoint of the pathologist but also from that of the clinician. For one interested in the problem, it comprises an excellent review of the whole general field.

The so-called degenerative diseases are becoming the most important group in our progressively aging population. Arteriosclerosis in its various forms is the most important single member in this group. Because of this fact, it behooves the profession as a whole to become more and more acquainted with and interested in this disease process. A great mass of investigative and pathological data has been assembled to date and this has been covered ably in a very brief and concise monograph, which undertaking has not been satisfactorily done previously, though several lengthy volumes have been written on the subject.

In spite of the great amount of literature available, arteriosclerosis still remains essentially a mystery, at least in so far as etiology is concerned, and probably as well as regards practicable therapy. From these viewpoints, the problem remains to be elucidated.

The author summarizes in 18 short chapters of a total 171 pages the following more important headings: arteriosclerosis, hypertension and arteriosclerosis, pathogenesis of arteriosclerosis, etiology of hypertension, mechanism of hypertension, Monckeberg's sclerosis, phlebosclerosis, sclerosis of the chambers of the heart, experimental arteriosclerosis, the relation of diabetes and arteriosclerosis, and diagnosis and prognosis of arteriosclerosis. He also reviews briefly the medical and surgical management of arteriosclerosis.

There are occasional interpretations of certain of the pathological features involved which may well be disputed by many of those having special interest and insight in the problem. Some of the terminology utilized is, of course, also different from that which others chose to use.

For those having interest in this disease and all its ramifications, this monograph is well worth reading, as it presents a brief summary of the knowledge to date regarding the problem. For detailed and com-

plete information on the special or allied subdivisions of the disease, one must consult the more lengthy individual monographs in great numbers.

ARTHUR I. BRATTON

WITHIN a volume of about 150 pages Dr. Colson¹ has covered the field of fractures quite completely. It is written in compendium style rather than outline. Every sentence is concise and clear in its brief explanation of the fundamentals and theories of fractures and fracture treatment. The 157 line drawings amply illustrate the text.

The author rightfully states that it was written for the undergraduate, as it is adequate as a reference work. A medical student having had only moderately good teaching in fractures could absorb this little book and pass any ordinary examination given on the subject. It should, therefore, be helpful to the undergraduate teacher.

J. J. M. THOMAS

THIS work by Paul Titus entitled *Atlas of Obstetric Technique*² is well conceived as to content and arrangement, and will doubtless fill a need in the post-graduate training of physicians in obstetrics and gynecology. The illustrations are excellent and well chosen to convey the idea the author has in mind. These, together with the comments are effective for the most part, in not only expounding the technique, but also in safeguarding the patient from misapplication of the various procedures.

However, as the book is designed "to be of interest and of some degree of value to general practitioners and obstetrical specialists alike," from the viewpoint of the general practitioner, one cannot but question the advisability of some of the illustrations. For example, there are a number of illustrations which illustrate myomectomy during pregnancy and several high forceps operations, giving undue emphasis without sufficient precautionary advice.

Isiotomy closure of skin with deep retention sutures of silk or linen "to be removed on the sixth day" does not seem to us to be the best method of closure. Similarly, closure of third degree lacerations by the use of silk, linen, or fine stainless steel wire for the rectal mucosa—knots being buried in muscle bed—does not seem good technique. Further, we would question the method for classical cesarean section, by abdominal incision two thirds below and one third above the umbilicus, a recommendation sure to be productive of postoperative ventral hernias if generally followed. And finally, the use of continuous catgut sutures while not commonly depicted could certainly be reduced to give a better concept of up to date surgery.

These criticisms are not serious ones when the book is perused and evaluated as a whole. It will form a valuable adjunct to all who have occasion to teach the technique of obstetrical procedures.

HERBERT F. TRAUT

¹ VASCULAR SCLEROSIS WITH SPECIAL REFERENCE TO ARTERIOSCLEROSIS. PATHOLOGY PATHOGENESIS ETIOLOGY DIAGNOSIS, PROGNOSIS, TREATMENT. By Eli Moschowitz A.B. M.D. London New York and Toronto Oxford University Press, 1942.

² FRACTURES AND FRACTURE TREATMENT IN PRACTICE. By Kurt Colson M.D. Johannesburg Witwatersrand University Press, 1942.

³ ATLAS OF OBSTETRIC TECHNIQUE. By Paul Titus M.D. St. Louis The C. V. Mosby Co., 1943.

It answers to long felt need of a *Handbook of Medical Library Practice* has been compiled and published. As is stated in the preface its purpose is to serve as manual of procedure and reservoir of useful data, and as supplement to general guides to library practice and the usual library school background. Each chapter is written by member of the compiling committee of the Medical Library Association. Chapters cover history and administration, book selection and ordering, cataloging, subject headings, classification, selection and handling of ephemeral material, pictures, microfilms, etc., rare books and the history of medicine and reference work. Appendices contain lists of medical libraries, expansion of medical classification schemes, and annotated bibliographies of reference books for the study of rare books and medical history (458 items) and other reference books (603 items).

This is the first attempt at a comprehensive guide for medical libraries and, as such, worthy of high praise and place on the shelves of every medical and scholarly library. However, it should not be used uncritically. The material on library collections in the United States is admittedly incomplete and, in some instances, definitely misleading. The balance of some sections is affected by the omission of important material believed to be covered in other manuals. Both inclusions and omissions in the reference sections are open to question. All of these criticisms were anticipated by the compilers.

After several years of trial, the book should be revised.

LOUISE WALKER

THE book, *Pain Mechanism* by W. K. Livingston, is thought-provoking work. Here is concept of pain and an interpretation of its possible mechanisms. The first section of the book deals with the anatomy and physiology of pain conduction. The middle portion is devoted to a consideration of clinical case histories and the final chapters to interpretations.

The author persistently searches for the how and the why. Because of the complexity of the subject, not all questions can be answered satisfactorily but each discussion is cautious, conservative, intelligent, and very worthwhile. One is impressed with the author's persistent search for the true cause of the pain in each case because he is of the opinion that there must be a reason for the pain if it can only be discovered. Of no less importance is the necessity for early control or eradication of the pain, if possible because pain frequently exceeds its protective function and becomes destructive. Of particular interest is his theory of the mechanism of the so-called vicious circle.

This book should be read by every student and practitioner of medicine and surgery.

GEORGE H. COLEMAN

In the past several direct studies of the human stomach have been conducted and reported in detail. The first by Beaumont was definitely pioneer work for that era and the facilities available during that period must be considered one of the foremost physiologic experiments of all times. Some 75 years later Carlson conducted similar experiment which added materially to our knowledge of gastric physiology. During the interval between these two elaborate experiments other similar studies of lesser scope were made. However, there still remained many mooted topics disclosed by meticulous clinical study enhanced by direct study of the stomach by the gastroscope. It could be reasoned that some salient features either had been overlooked or not brought into the previous studies; therefore, the report by Wolf and Wolff is not only interesting but advantageous.

The subject studied was a male, 40 years of age, had been fed through gastrostomy opening because of complete obstruction of the esophagus. This report is unusually interesting because the subject was apparently in state of excellent nutrition and exhibited the types of observations and experiments employed since he manifested many of the psychic reactions so prevalent at this time such as anxiety, fear, depression, and pride. Basic studies of motor and secretory activity and vascularity were made. These were found to vary greatly under various conditions. The effects of heat and cold, smoking, and sundry drugs such as atropine, antacids, epinephrine, vasodilators, and constrictors were noted. Also the effects of the direct application of mechanical trauma, alcohol, mustard and many other substances that are commonly eaten or given in the course of medication were studied. The reactions in many instances were contrary to generally conceived ideas. Probably the most interesting phase of the study was observing the reactions evoked with varying emotions such as the relaxation, engorgement of the mucosa of the stomach, its re-orientation and mucosal erosion associated with anemia, hyperacidity, hypermotility and adherent coagulated mucus associated with sustained reversion. The observations further seemed to verify the previous conclusion that mucus is the great protective agent for the gastric mucosa.

No dogmatic conclusions regarding, however, the authors suggest thesis that warrants serious consideration. It is rather well summarized in paragraph in the final chapter. Consolidating physicians and placing reliance on ideas gives the patient the conviction that he is being backed up and his feeling of being caught, of being alone or of frustration are mitigated. F. Ribnermer, his reliance on the

HENRY MARION F. WOLFF, EXPERIMENTAL STUDY OF HUMAN STOMACH BY SURGERY and MEDICINE, M.C. A.S.S., and GEORGE C. WOLFF, M.D., London, New York, Toronto, Oxford University Press, 1943.

A HANDBOOK OF MEDICAL LIBRARY PRACTICE, INCLUDING ADVANCED BIBLIOGRAPHICAL GUIDES TO THE LITERATURE, IN MEMORY OF HER MAJESTY THE QUEEN ELIZABETH, Edited by ALICE STEVENSON, with the assistance of M. Irene Jones. Compiled by Committee of the Medical Library Association. Edited by J. Hart Day. Chicago: American Library Association, 1943.

PAIN MECHANISM, PHYSIOLOGICAL INTERPRETATION OF CAUSATION, by W. K. LIVINGSTON. Edited by M. C. A.S.S., and GEORGE C. WOLFF, M.D., London, New York, Toronto, Oxford University Press, 1943.

physician lessens the additional threat which merely being ill offers the patient's security. At the first sign of improvement from a regime of alkalis and cream, his horizon appears brighter. The hyperaemia and the engorgement of his mucosa related to his reaction are reduced. Pain and tissue damage occur less readily. The chain has been broken. If one can prevent new links from being forged, the patient continues to improve."

The impression obtained, however, is that the observations noted have a far greater significance than appears on the surface. This little monograph bears reading and re-reading. It will stimulate other studies that may reveal some of the mysteries of adverse responses of the human body to causes hitherto unsuspected.

JOHN A. WOLFER

THE 300 page book *Manual of Fractures*¹ by Shaar and Kreuz is concerned with the treatment of fractures by external skeletal fixation embodying the use of the Stader splint. It is based on an experience with over 157 cases of various types of fractures and orthopedic problems occurring in healthy young adults cared for in a Naval hospital. It stresses the point that fundamental principles of accurate reduction, rigid uninterrupted fixation and early restoration of function are accepted as axiomatic in the treatment of fractures. The manual is intended for those surgeons in military service, particularly Naval, (the Army frowns upon the use of the Stader splint) who must care for numerous casualties in a short space of time, often under difficulties.

Essentially the Stader splint is lauded as fulfilling all requirements for rigid fixation and for transportation, even for long distances over land or sea, of patients suffering fracture. No claim is made that the method of external fixation, acknowledged as an old one, is a short cut to fracture treatment and healing and it is stressed that the training of the surgeon in mechanical and physiologic methods and knowledge is required.

Nine sections of the book divide it into 27 chapters of irregular size, some extremely brief. In sequence the sections discuss: (1) general consideration of external skeletal fixation including the principles of Stader reduction and fixation splint, (2) the Stader splint including mechanical principles and methods of application, (3) delayed union and nonunion including the relation of external skeletal fixation to these problems, (4) descriptive chapters on fractures of the mandible, clavicle, humerus, radius and ulna, femur, pelvis, tibia and fibula and os calcis, (5) complications in fractures, compound fractures, with osteomyelitis, old ununited fractures and non union, (6) arthrodesis of joints, knee and hip, (7) bone grafts, (8) incidence of fractures in the service, (9) anesthesia and x-ray study used in external fixation. Section IX, comprising 50 pages, is written by Lt. Commander D. I. Hale and the roentgenologic

study by Lt. Commander S. L. Casper. For good measure an appendix on the treatment by skeletal traction, of fractures at sea, is added.

The technical methods of application are well described and although warning is given that external skeletal fixation is not for every fracture, a clear list of contraindications for its use is not given. The chapter on fractures of the mandible is perhaps the best. The cause and mechanism of pin seepage and the description of the Stader splint are well done and illustrated. One learns that several different sizes of splints are required, depending on the bone to be splinted, and that a rather cumbersome two-man hand drill is needed for boring holes in the bone. No mention is made of the possible cost of these outfits for civilian hospital use.

Like any other manual this one cannot completely cover the treatment of all fractures. It is a specific and illuminating report on external fixation methods. The format is good, the illustrations numerous, but not always thoroughly informative, and there are a shockingly large number of split infinitives in the text. One feels that the text may have been rather hurriedly assembled and that the extremely terse sentences and widely used outline style represent skeletal notes as well as skeletal fixation. The experiences and methods given will be profitable to those treating fractures, understanding as expressed by the authors that these old and revived methods are not cure-alls.

KELLOGG SPEED

THE 684 page book *Rehabilitation of the War Injured*² edited by Doherty and Runes is in the nature of a symposium on a collection of carefully chosen articles on the rehabilitation of certain selected types of war, and in a few instances, of industrial injured. The contributors are chiefly British medical officers who have had wide experience in the fields of reconstructive surgery, neurology and neurosurgery, psychology, blindness and deafness, amputations, tuberculosis, medicolegal problems connected with pensions and compensation, and the rehabilitation methods pertinent to the disabled in these various fields.

Rehabilitation is referred to as a new department in the practice of medicine, yet reconstructive surgery and rehabilitation were born in the throes of World War I. We note the same ideals and the same definitions for the rehabilitation of the present war injured as were expressed in the previous war, viz., the physical and mental reclamation of the disabled as far as was humanly possible and their restoration as useful members of society rather than as pensioners and dependents robbed of incentive and initiative.

The chapters on the rehabilitation of the victims of head injuries are especially valuable. Not even one intensely interested in the care of brain injuries can read these contributions without being aware of

¹ MANUAL OF FRACTURES. TREATMENT BY EXTERNAL SKELETAL FIXATION. By C. M. Shaar, M.D., F.A.C.S. and Frank P. Kreuz, Jr., M.D., F.A.C.S. Philadelphia and London: W. B. Saunders Co. 1946.

² REHABILITATION OF THE WAR INJURED. A SYMPOSIUM. Edited by William Brown Doherty, M.D. and Daobert D. Runes, Ph.D. New York: Philosophical Library, 1945.

his own shortcomings in handling cute head injuries in such way as to avoid the psychoneurotic aftermaths which are so frequent and often so permanently disabling. In fact the book is so filled with common sense lessons in the art of rehabilitative medicine that no physician regardless of his specialty should miss reading it.

We recommend it especially to the medical officers in our Army and Navy. The chapters on plastic su-

gery the care of burns, the remedial treatment of scars and amputations, as well as those dealing with special defects such as blindness and tuberculous are packed with concise, useful information. It stirs your imagination and carries your viewpoint beyond the immediate care of the wounded. It makes you a definite link in the rehabilitation of every disabled soldier that passes through your hands.

HARRY E. MOCK.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

THE 1943 YEAR BOOK OF RADIOLOGY DIAGNOSIS edited by Charles A. W. Terry, M.D., and Whitcomb B. Flier, M.D. THERAPEUTICS edited by J. I. Kapler, B.Sc., M.D. Chicago: The Year Book Publishers, Inc. 1943.

EXPERIMENTAL SURGERY. A LABORATORY OUTLINE FOR UNDERGRADUATE STUDENTS. By J. M. McCaughan, B.S. M.D. Ph.D. St. Louis: The C.V. Mosby Co. 1943.

MANUAL OF SURGERY. By Ross & Carmichael. American (6th) ed. Edited by William T. Coughlin, B.S., M.D. F.A.C.S. From 6th English ed. by Cecil P. Q. Walsby D.Sc., F.R.C.S., F.R.S.E., F.R.S.A., F.A.C.S. F.R.A.C.S. and John B. Hunter M.C. M. Ch. Cantab. F.R.C.S. Ling. Baltimore: The Williams & Wilkins Co. 1943.

NOTE FOR THE R.M.O. OF THE TEST UNIT. By C. P. Blacker, M.C. M.A. M.D. F.R.C.P. Oxford War Manual. Edited by Rt. Hon. Lord Horder G.C.V.O. London: H. K. Lewis Ltd. (Oxford University Press) 1943.

WHITE BLOOD CELL DIFFERENTIAL TABLES. By Theodore R. Waugh, B.A. M.D. C.M. New York and London: D. Appleton-Century Co. Inc. 1943.

HOLT'S CARE OF FEEDING OF CHILDREN. Revised and enlarged by L. Emmett Holt, J. M.D. New York and London: D. Appleton-Century Co. Inc. 1943.

A SYNOPTIC OF SURGICAL ANATOMY. By Alexander Lee McGregor M.Ch. (Ed.) F.R.C.S. (Eng.) With

Foreword by Sir Harold J. Stiles, K.B.E. F.R.C.S. (Eds.). 5th ed. Baltimore: The Williams & Wilkins Co. 1943.

THE FOOT. By Norman C. Lake, M.D. M.S. D.Sc. (Lond.) F.R.C.S. (Eng.). 3d ed. Baltimore: The Williams & Wilkins Co. 1943.

TRATADO FOLIO DE GUERRA. By Dr. Toranzo Gola. Buenos Aires: Alerio Lopez, 1943.

LIBRO DE ORO DEDICADO AL PROFESOR DR. ALBERTO BURELLO, 1905-1942. Rosario, Rep. Argentina: Falso Falso 1943.

PAID PROCEEDINGS OF THE ASSOCIATION, DECEMBER 3-10, 1942. NEW YORK: Research Publications of the Association for Research in Nervous and Mental Disease, Vol. 3. Edited by Harold G. Wolff, M.D. Herbert S. Gasser, M.D. and Joseph C. Murray Ph.D. Baltimore: The Williams & Wilkins Co. 1943.

SURGICAL ERRORS AND SURVEILLANCE. By Max Thorch, M.D. LL.D. D.C.M. F.I.C.S. With Foreword by Sir Hugh Dennis, M.S. Hon. F.R.C.S. (Eng.), F.R.A.C.S. F.A.C.S. (Hon.) and chapter on Legal Responsibility in Surgical Practice by Robert Wootton Smith, A.B. M.B.A., LL.B. M.D. 4th ed. Philadelphia, Montreal, and London: J. B. Lippincott Co. 1943.

THE HOSPITALITY MOVING SOCIETY. Edited by Arthur C. Bachmeyer, M.D. and Gerhard Hartman, Ph.D. New York: The Commonwealth Fund, 1943.

BACKACHE AND SCIATIC NEURALGIA: BACK INJURIES—DEFORMITIES—DISEASES—DISABILITIES. With Cases on the Pelvis, Neck, and Brachial Plexus. By Philip Lewis, M.D. F.A.C.S. Philadelphia: Lea & Febiger 1943.

year ending August 1919. The work at these two army hospitals was reported in some detail by various members of the staffs and these reports dealt largely with the clinical examination, electrodiagnosis, operative technique and general care of patients observed in these centers. The investigation of nerve injuries in the army reconstruction hospitals was carried out by competent neurologists who were given sufficient personnel to make thorough and repeated examinations in all cases.

Practically all soldiers with peripheral nerve injuries were returned to this country for definitive surgical treatment. It was generally appreciated that the problems of peripheral nerve surgery should be dealt with in a reconstruction hospital and not in the war zone. Frazier states that of the Cape May series of more than 500 cases, only 5 injured nerves had been sutured overseas. Nearly all of these patients had received injury between July and November 1918 and few operations were performed before January of the following year the majority being done from April to August 1919. It should be noted here that there was a considerable period between the injury and secondary surgical treatment for nerve repair. This long delay was unfortunate because it gave ample time for the development of muscular atrophy, fibroses and other crippling sequelae of long continued denervation. The delay in operation in many of those that needed it badly was due to two principal factors. In the first place there was residual infection in many of the wounds occasioned by osteomyelitis or retained foreign bodies, and this infection was often eradicated slowly.

The attitude toward nerve injuries in European hospitals had been a conservative one and that conservatism had some justification in the reports of a rather considerable percentage of spontaneous recoveries following paralysis of the extremities resulting from gunshot wounds which had not directly injured the nerve but had caused a physiological interruption for varying lengths of time. Frazier believed that about 6 months should be allowed between the injury and operation on the injured nerve. This would allow sufficient time for complete healing of the wound

in infected cases and for evidence of spontaneous recovery if this were possible. The conservative attitude which prevailed in the early part of the reconstruction period after the Armistice was perhaps influenced to some extent by the fact that American surgeons at the time were without experience in the treatment of nerve lesions. Few of them had performed as many as a half-dozen peripheral nerve operations prior to 1918. The writer was convinced in his early experience with these injuries at Cape May that the attitude toward exploration of nerve injuries should be more radical than that which prevailed when the peripheral nerve centers were first established in this country and that exploration of the paralyzed nerve was often the only way to obtain the information necessary to proper treatment.

The factors of delay such as infection and lack of experience with the treatment of nerve lesions, will not be operative in the present war to the same degree as in 1918. The prevention or control of infection has vastly improved through chemotherapy thus insuring the practicability of early exploration of the paralyzed nerve and this should be the rule. While accepting the value of chemotherapy for the control or prevention of infection we feel that it can by no means be a substitute for adequate surgery nor have we used it in any wounds except those in which we felt that complete disinfection could not be accomplished mechanically with normal saline or Ringer's solution. In this connection Holmes and Mediwar following experimental findings, have warned that sulfanilamide should be used locally with caution in operations in which the nerve trunk is exposed. They reported that if as much as 3 grams (a rather large amount under the circumstances) of this drug were applied along the course of the sciatic nerve in rabbits there was histological and functional evidence of nerve damage even though the nerve was protected by a film of fascia.

Another important cause of delay in the suture of divided nerves in World War I was the misleading signs of regeneration which led to failure of recognition of the type of lesion present. Too much reliance was placed on

Tinel's sign which was considered by some in the earlier work at reconstruction hospitals as possessing a high degree of infallibility. Time and again patients with Tinel's phenomenon indicating, as was then supposed, regeneration of the nerve, were found at operation to have separated bulbous nerve ends without the slightest possibility of regeneration.

Nerve injuries of warfare are usually far more complicated than those in civilian life. Communion of bone and injury to the muscles, large blood vessels and sympathetics of the extremities, often are associated with the nerve lesion. The complexity of war wounds of peripheral nerves not only adds to the difficulty of surgical treatment but also constitutes an important factor in the limitation of functional recovery.

We have seen no case of serious vasospasm associated with peripheral nerve injury in civilian practice. Two cases have been reported by Colonel J. A. McFarlane from experience in the present war. In one case there was a bullet wound of the thigh with a small hemorrhage of the sciatic nerve and the other followed fracture of the tibia and fibula in the middle third, without important vascular injury in either case. One case had a periarterial sympathectomy. Both finally required amputation of the extremity above the knee. Obviously, severe vasospasm, if it develops at all, would develop shortly after injury but a lesser degree of vasospasm may be seen later in cases in which the sympathetics have been injured. In some cases of severe partial nerve lesions in civilian practice, showing evidence of vasospasm with causalgia, we have used injections of the paravertebral sympathetic ganglia for improvement of the circulation of the involved extremity, relief of pain and for its indirect benefit to nerve regeneration by improving the peripheral circulation. We are of the opinion that there might be a wider field for the employment of this procedure in certain partial nerve lesions, particularly those with causalgia.

As the study of peripheral nerve injuries progressed in the Army hospitals in 1919, it became evident from a number of operations that the nerve lesions as a rule were more serious than the clinical study of the patients

had indicated. It may be mentioned at this point that the tendency to underrate the extent of nerve lesions or even ignore them altogether is common in civilian practice. A more radical attitude toward exploration gradually developed in the Army cases which showed no improvement. It was not recognized at the time that exploration of a nerve is the only satisfactory way to obtain exact information as to the true nature of the lesion in many cases. When there is complete paralysis of a nerve following gunshot wound, we believe that exploration of the nerve should be done as soon as the condition of the wound is satisfactory. If it should be found on exploration of gunshot cases that suture of the nerve is not required, freeing of the nerve from scar may favorably influence regeneration. Nerves paralyzed by stab wounds should be sutured when primary treatment is given.

Exposure of peripheral nerves to obtain definite information of the lesion can be done with little risk to the patient or the nerve by those experienced in this type of surgery. The exposed lesion may be either partial or complete division of the nerve, or a neuroma in continuity. If the nerve is partially or completely divided, the indications for specific surgical treatment are clear. However, if a neuroma in continuity is present, expert surgical judgment may be required to decide whether the neuroma should be excised and direct suture made or whether the operation should consist merely of freeing the nerve from its bed of scar or pressure from callus formation. Obviously, if the muscles respond upon faradic stimulation of the nerve applied above the neuroma, neurolysis would be considered sufficient. Some idea of the regenerative possibilities of the paralyzed nerve may be obtained from the consistency of the neuroma, a firm resistant neuroma indicating an impermeable obstruction from intraneural scar. Excising of the neuroma and direct suture is required in such cases (Figs 3 and 8). It was common practice in the Army hospitals of World War I, when attempting to make a decision as to whether the neuroma should be excised or simply freed from scar, to inject saline solution under the covering of the neuroma for the purpose of disclosing the

condition of its neural contents. On the whole the investigation of the neuroma by all approved procedures often fail to give satisfactory information as to how much the scar formation will permanently obstruct regeneration. It is generally believed that it is best to perform a neurolysis in doubtful cases with later resection and suture if the neurolysis fails to restore function.

Divided nerves retract leaving a considerable gap between the ends which later develop bulbous neuromas. Wide separation of the ends may result from too energetic débridement of gunshot wounds by those unfamiliar with anatomy of the extremity. In the writer's experience in the Army cases, there was considerable separation of the bulbous ends of the nerves at operation in the majority of cases (Fig. 2). It is highly desirable at the primary treatment of a gunshot wound when division of the nerve is recognized, that the ends of the nerve should be tied together to prevent further retraction and enable a more satisfactory suture at secondary operation. In a few favorable cases in which the nerve ends are easily approximated a satisfactory suture may be done at the primary operation for disinfecting the wound. Extensive dissections of the nerve at this time should not be done.

The problems of nerve suture have centered largely about methods of approximation of the nerve segments without great tension after resection of the scar tissue. All the methods for gaining distance when the nerve ends are widely separated are well known and need only be mentioned.

The simplest method for gaining distance when the nerve ends are separated is to place the extremity in the posture that will provide the greatest relaxation of the nerve. This is particularly applicable to the sciatic nerve

(Fig. 6) but is helpful to some degree in the suture of all peripheral nerves (Figs. 9 and 10).

Transposition of the nerve to a more direct course is sometimes necessary especially in ulnar and musculospiral lesions with loss of nerve substance (Figs. 1 and 5). In transposing the ulnar nerve the trunk is removed from its position behind the internal condyle to a new bed on the flexor surface of the forearm. In the new position, flexing the extremity gives considerable relaxation of the nerve trunk. Transposition of the nerve is also useful in cases of traumatic ulnar neuritis, to protect the nerve from further injury. In transposition of the ulnar nerve its branches to the forearm muscles should be carefully protected to prevent additional impairment although in extreme cases, with considerable loss of nerve tissue it may be necessary to sacrifice certain branches of the ulnar to the forearm muscles in order to restore the more important innervation to the intrinsic muscles of the hand.

Gentle stretching of the nerve at operation will gain distance to a limited extent (2 cm.). In this procedure more force should be used on the degenerated distal, than on the proximal segment.

Whenever a considerable gap in the nerve trunk is disclosed at exploration or a long neuroma is continually requiring excision is exposed. It is most important to decide before excising the scar tissue from the nerve whether the healthy nerve segments can be approximated without excessive tension by one or more of the methods for gaining distance previously mentioned. If satisfactory approximation seems unlikely the limb should be put in the optimum position for relaxation of the nerve and the neuromatous ends tied together with heavy silk sutures. Then over a period of 3 to 4 weeks the position of the limb may be

Fig. 4. a, Division of the ulnar nerve at the wrist with fracture of the ulna by shell fragments. Scar of incision as shown. b, dense scar in along the nerves and muscles. c, the dorsal branch of the ulnar has been completely divided and large irreparable neuroma is shown on the palmar branch. After preparation of the nerve for suture, gap of 4.5 centimeters as present and the ends could not be approximated. d, graft from musculocutaneous of the leg was used for transplantation. The grafts are shown in position. In small nerves such as the ulnar after its biliary cation, it would seem that autogenous grafts could have

definit. Held. her direct approximation cannot be secured.

Fig. 5. Large lateral neuroma of the left ulnar nerve. a, Line of incision. b, exposure of the median and ulnar nerves. c, median nerve intact. d, lateral neuroma involving so much of the nerve that it did not seem feasible to attempt nerve the few fibers remaining intact. The neuroma is completely excised. The femoral of the healthy nerve and after excision of the neuroma are shown. e, the nerve as removed from its normal bed and shifted to an anterior position to gain distance. The branches to the forearm muscles are protected. The transposition

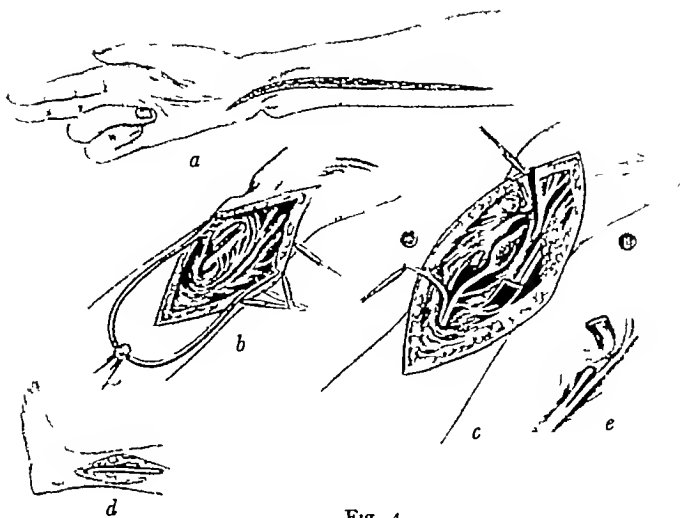


Fig 4.

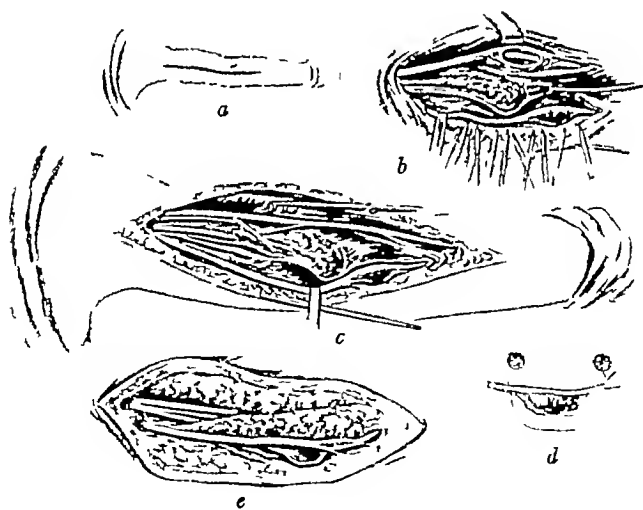


Fig 5

Surgical Treatment of Peripheral Nerve Injuries —
Claude C. Coleman

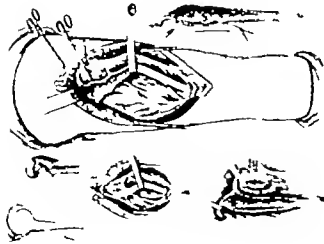


Fig. 6

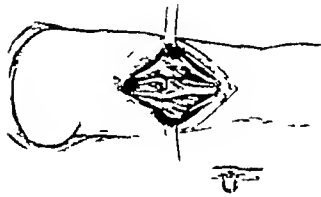


Fig. 7

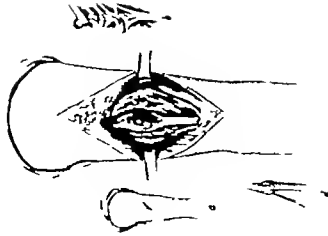


Fig. 8

Surgical Treatment of Peritoneal Verruca I. Jureta—Claude C. Colson

gradually changed to that which produces the greatest tension on the nerve. Thus the nerve may be lengthened sufficiently to permit excision of the neuromas and approximation of healthy nerve ends without tension. We do not believe that careful gradual stretching of the nerve impairs its recovery after suture. It is probable that the elongation of the nerve trunk under such circumstances is due to growth of the nerve segment as well as stretching.

In a long neuroma in continuity when it is obvious that complete excision of the scar would create a gap too wide for satisfactory approximation, only the central portion of the neuroma should be excised, leaving sufficient scar tissue at each end for temporary tension sutures for gradual stretching of the nerve. If it should happen that approximation of the nerve ends cannot be made without excessive tension after complete excision of the scar tissue and should gradual stretching then be found necessary, the situation would be most unfortunate because further loss of nerve tissue would result from passing traction sutures through the healthy nerve ends from which the neuroma had been excised.

Another procedure for reducing the gap between nerve segments is resection of one of the long bones. This operation has been most often applied to the humerus when more than one nerve is injured. Resection of the humerus to make possible direct suture of the median and ulnar nerves was done a few times in the Cape May series and it has been used by the writer in 3 cases in civilian practice. In the writer's opinion the operation has a definite

field of usefulness but is rarely necessary and should be considered only when other less drastic methods for gaining distance have failed to bring about sufficient relaxation of the nerve.

Transplantation of nerves to overcome defects continues to receive much attention (Figs 2 and 4). Animal experimentation provides histological evidence of the success of nerve transplants but this has had little support from clinical experience. Experimental transplantation of nerves was extensively investigated by Huber and his associates, Dean Lewis, Byron Stookey, and others in the Army laboratory authorized by the Surgeon General in World War I. The work of these investigators covered practically all phases of nerve regeneration from the experimental standpoint, and the published results are being confirmed by studies at the present time. The attitude toward the benefits of transplantation appears to be determined largely by whether the transplants are used in experimental laboratories or upon nerves of human beings. Generally speaking, surgeons have regarded the method as a failure. The functional results of nerve transplantation in the Cape May series so far as the writer knows were entirely disappointing. Not a single patient, examined by me, showed the slightest evidence of recovery of useful function. Perhaps the Tinel sign showed some evidence of down growing nerve fibers but this was all.

Robert Jones reported a large number of cases in which operations were carried out by transplantation, with 1 patient recovering function, a few obtaining partial recovery

Fig 6 High gunshot wound of the sciatic nerve a, fracture of femur caused by the missile, b, exposure of the nerve below the dense scar, c, further dissection of the nerve and exposure of muscular branches, d, the nerve is dissected free from scar tissue. Appearance of a very large dense neuroma in continuity, e, a tension suture is placed through healthy nerve about 1 centimeter from each end of the neuroma. The neuroma is excised and direct suture made without tension after flexion of the leg on the thigh. This position is maintained for 2 weeks, f, line of incision for high lesions of the sciatic nerve. In lesions about the level of the pyriformis the tendon of the gluteus maximus is divided. This incision allows rapid exposure of the nerve and was first used by the writer in 1919.

Fig 7 Partial division of sciatic nerve in the mid thigh and completely severed the external popliteal con-

the internal popliteal division. In this case division of sciatic into its two main branches was at a higher level than usual a, The neuromas have been removed and suture of both the external popliteal and the sever portion of the internal is done. The loop of the ureter of the nerve is shown. In sciatic lesions type, preservation of the intact portion during suture easily accomplished than in any other peripheral nerve a, Scar

Fig 8 Gunshot wound of sciatic nerve a, Scar shot wound of upper thigh, b, beginning exposure of the nerve is illustrated. The branch to the semitendinosus has been protected during the dissection. Excision of the neuroma left a defect of 3.5 centimeters. The branch to the semitendinosus is completed suture. The branch to the proximal semitendinosus is sutured to the inner surface of the proximal semitendinosus. In this case two tension sutures seemed advisable.

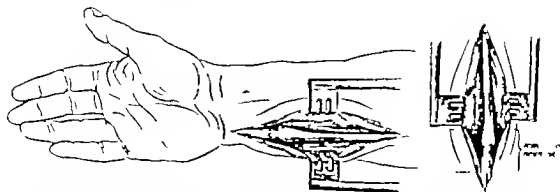


Fig. 9. Division of left ulna nerve by glass just above its bifurcation. Appearance of nerve 7 months after injury

Large neuroma developed in proximal segment. a, Resection of the neuroma leaves gap of about 3 centimeters.

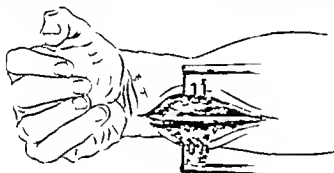


Fig. 10. Completed suture with hand in palmar flexion

but most of the cases ended in complete failure.

Davis and Pollock acknowledge the promising result of experimental transplantation but state that the clinical results had been disappointing.

It may be that results of transplantation can be improved by the method advocated by Davis and Cleveland by later resection of the distal suture line of the transplant with resuture. This procedure has also been advocated by Bentley and Hill. We have seen no reports of this procedure in clinical cases. Such a resection of the distal part of the transplant was done by the writer in 1 case and resuture of the transplant was done (Fig. 9). Studies of the specimen showed penetration by the proximal axones into the transplant for a distance of about 2 centimeters. The appearance of the remainder of the transplant imbedded as it was in dense scar certainly gave

no indication that functional recovery would take place. The interposition of small autogenous cable transplants suggested by Huber and his associates seems inadequate to restore the continuity of the larger peripheral nerves in man. Later exploration of such transplants is likely to show in most cases impermeable barriers of scar tissue.

We believe that there is a field for nerve transplantation in defects of small nerves such as the facial or the nerves of the hand. In small nerves the distance would likely be short and this would be a matter of considerable importance to successful regeneration through the transplant. Autogenous transplants may be taken from other nerves of little importance. The success of transplantation of small nerves has been proved by both clinical and experimental results.

When restoration of nerve function is manifestly impossible and this may be the

case in lesions of the posterior interosseous and the external popliteal a substitute for nerve action may be found in transplantation of the tendons of normal muscles to take over the action of those which have been denervated. A familiar example of such transplantation is in the use of the flexor carpi radialis and ulnaris to the common extensors of the fingers and extensors of the thumb to produce extension of the hand, fingers and thumb when the posterior interosseus cannot be repaired.

Certain procedures for nerve repair, such as nerve flaps, nerve implantation and direct implantation into muscle, enjoyed a brief use before the futility of such procedures was recognized. A very ingenious proposal for reuniting divided nerves was suggested by Young and Mediwar in 1940 from experiments carried out in animals. This method consists of joining the nerve ends by a coagulated plasma cuff. So far as I know, this procedure has not been used clinically and it would seem to have definite limitations because of the low tensile strength of the cuff which makes it unsuitable for clinical cases. Perhaps a combination of plasma cuff and suture might offer some advantages in certain cases.

It is universally agreed that direct suture of healthy nerve ends is the only satisfactory method of repairing divided nerves. The wound should be well healed although Ballance and Duel appear to have found infection no obstruction to regeneration in the grafting of a facial nerve following mastoid operation.

The technique of nerve suture has received considerable attention and at the present time it is essentially that generally used in the first World War. We have seen in the literature only a few variations from this technique and these apparently are not of sufficient importance to affect materially the results of suture. Practically all writers on nerve suture recommend exposure first of the nerve trunk above and below the scarred area with later approach to the lesion itself. A tourniquet is not only unnecessary, but it may produce further serious damage to the nerve and muscles of the extremity.

The writer has always used fine interrupted silk suture for approximation of the epineu-

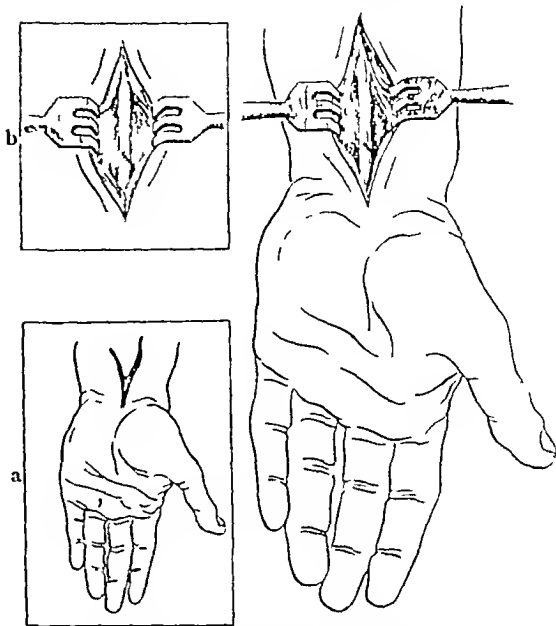


Fig 11 Partial division of the left median nerve by glass. There is practically no loss of nerve substance. a, "Y" shaped laceration of the wrist. No tendons were divided, b, suture of the divided portion of the nerve performed a few hours after injury.

rium with one No 00 plain catgut or fine silk intraneural tension suture passed through the nerve about $1\frac{1}{2}$ to 2 centimeters from the ends to hold the segments in apposition while the epineurium is being approximated and to maintain accurate approximation after suture (Fig 13). The relaxation suture is unnecessary when there is no loss of nerve substance as in stab wounds operated upon before retraction takes place (Fig 11).

Recently fine steel wire sutures have been proposed by Colonel W V Cone at the Canadian Neurosurgical Hospital, Basingstoke. Other surgeons, notably Lt Colonel R Glen Spurling, use tantalum wire instead of silk as a suture material. It is claimed by those who have used tantalum that it is less irritating than silk and a further advantage of tantalum is that the integrity of the suture line may be demonstrated by later x-ray examination. We think the second point is of some importance, but we have not been convinced that tantalum has advantages over silk in so far as the functional results obtained are concerned.

In the approximation of nerve segments for suture it has always seemed important to the writer to maintain the normal alignment of the nerve as nearly as possible. In order to prevent rotation of the nerve during suture we have placed fine silk knots in the epineurium in the same plane above and below the level of the lesion before the nerve is removed from its bed of scar tissue. The appearance of the nerve ends may sometimes furnish information as to the normal alignment. Therefore the nerve ends should be carefully inspected for corresponding blood vessels in either segment to indicate the correct pattern of the approximated nerve. The importance of preventing rotation is perhaps greatest in those nerve lesions in which little of the trunk has been lost. Because of the rather rapidly changing topography of the nerve trunk torsion of the nerve segments is of less importance when a considerable gap exists.

The dissection and manipulation of the nerve trunk in freeing it from scar tissue should be done with great gentleness and much care is necessary in some cases to avoid injury to important branches imbedded in dense scar.

In preparation of the nerve for suture scar tissue is removed from the neuromatous ends in thin serial sections with a razor blade held in a hemostat each section being carefully inspected for scar tissue and nerve fibers. As the section approaches healthy nerve bleeding from the nerve increases and the funiculi become apparent. It seems unnecessary to use any chemical to identify the nerve fibers thus exposed. They should be recognized with the naked eye before the nerve is considered properly prepared for suture. The end of the nerve when prepared for suture should be smooth with no irregular projection of the funiculi. Hemorrhage from the nerve ends may be controlled by gentle pressure with wet cotton pads or temporary application of a muscle graft. Accumulation of blood between the sutured segments militates against functional recovery. The epineurium is carefully approximated with interrupted sutures of arterial silk after complete hemostasis of the nerve ends. The originally placed intraneural suture should then be tied with sufficient ten-

sion to relax the intervening nerve trunk and bring into accurate apposition the cut surfaces of the nerve ends. In very small nerves such as a branch of the facial an epineural suture may be impracticable. Careful end-to-end approximation of the nerve segments with a fine through-and-through suture is usually sufficient in such cases (Fig. 13).

Various types of material have been used to protect the sutured nerve from invasion by scar tissue. Spurling recently has been wrapping the line of suture with tantalum foil. This has not been used sufficiently long to determine its effect on regeneration. In the writer's opinion, it is doubtful that any nerve wrapping accomplishes the purposes for which it is intended. It is rather widely believed that instead of protecting the nerve from scar tissue wrapping materials often increase scar formation. In most cases complete hemostasis of the wound and placing the nerve in a muscle bed will assure minimal scarring about the nerve. In certain cases in which the nerve has been mobilized for some distance or when the soft tissue support has been extensively destroyed it is possible to give some protection to the nerve by placing a well vascularized pedicle of fat beneath it. Coating from small vessels may be controlled by coagulation with the electrosurgical unit and this materially shortens the time of operation.

The repair of partial defects in peripheral nerves is most easily done in the sciatic in the middle portion of its course where one of the main constituents may be divided without injury to the other (Fig. 7). In such cases the repair of the nerve trunk is effected by separation of the nerve trunks above and below the lesion to prevent excessive angulation of the undamaged companion nerve by suture of the divided trunk. The difficulties of repairing a partial lesion are greater in other nerves in view of the fact that a single nerve trunk must be split longitudinally above and below the lesion in order to approximate that portion of the nerve which has been severed. Thus a certain amount of damage to the nerve trunk above and below the lesion is inevitable and it is better in cases when the lesion is almost complete to divide the nerve entirely and follow the technique of direct suture.

A rather frequent type of injury which should be mentioned, though not usually requiring operation, is injury of the musculospiral nerve in fracture of the humerus. A temporary paralysis is not uncommon, but spontaneous recovery occurs in a large majority of cases. Operative reduction and fixation of the fracture should be done carefully to avoid further damage to the nerve. In some of these cases, forcible traction from displacement of bone fragments and subsequent scar tissue formation may damage the nerve over a considerable distance. The nerve may be scarred, flattened and attenuated, and satisfactory operation upon the nerve may be a procedure of great difficulty.

Injury to a nerve trunk by severe traction presents rather difficult problems in treatment. It is unusual for the nerve trunk to be completely divided by the traction force but injury to the nerve may extend over a considerable distance, making it difficult if not impossible to determine how much of the nerve has been damaged. Nerve traction injuries are not uncommon in external popliteal nerve.

Following suture of a nerve, the extremity should be kept in the proper position for the maximum relaxation of the nerve and this position maintained by a plaster cast for 2 weeks. We believe that a longer period of plaster fixation not only is unnecessary but is detrimental in that it interferes with physical therapy. We have never had a suture line rupture except on one occasion during operation when the limb was dropped by an inattentive assistant.

The care of the paralyzed extremity is of greatest importance both before and after operation. The effects of massage, electrotherapy, and passive movements have not yet been agreed upon. Massage is generally resumed after the 3d postoperative week, and the writer believes it to be helpful. Moreover, it produces a better mental attitude in patients, many of whom will be under medical care for months. The effects of vitamin deficiency in its relationship to regeneration of peripheral nerves has been considered and deserves further investigation. The fact that nerve tissue in general may suffer in vitamin deficiency naturally leads to the consideration



Fig. 12 Incision for exposure of high lesions of the musculospiral, median, and ulnar nerves. It is often necessary to divide the tendon of the pectoralis major muscle. The incision is well away from the axilla. Should approximation of the arm to the chest be necessary to relieve tension on the nerve, the skin incision is still accessible and may be readily sutured.

of the effects of such deficiency in the recovery of nerve lesions.

The splinting of paralyzed muscles is a very important part of the treatment of peripheral nerve lesions in combination with the surgical repair as well as in many cases when surgical treatment is not required. This important adjunct is often omitted in civilian practice. The splinting should be continued until muscle function is sufficiently restored to prevent the stretching of the paralyzed muscles. The most favorable nerves for splinting are the musculospiral and anterior tibial. The splints devised by R. C. Buerki at Cape May for these two nerves incorporate all the requirements of successful support and have been used by the writer in preference to all others.

In cases following sciatic nerve suture, a splint, hinged at the knee, may be used which will permit flexion of the leg, and at the same time, limit extension sufficiently to prevent excessive tension on the suture line. Such splints are easily applied and were used in the cases of the first World War.

Peripheral nerve injuries in civilian practice requiring operation are most often caused by sharp instruments and fragments of glass with little loss of nerve tissue or destructive associated injuries. With adequate primary treatment there should be no infection of the wound. Under such conditions the best possible functional results should be expected.

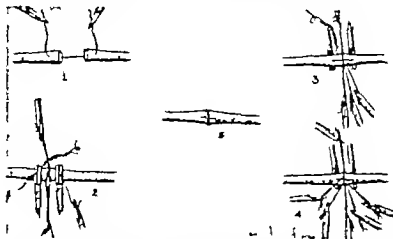


Fig. 3. Technique of direct nerve suture. Silk knots are placed in the epineurium of each nerve segment to indicate proper alignment. A tension suture of fine silk is used for approximation of the nerve ends during suture. 2, By slight traction on the two ends of the tension suture the prepared ends of the nerve segments may be held in position. Each end of the tension suture is then clamped with rubber covered mosquito forceps, close to the nerve to maintain approximation. The epineurium is carefully approximated for one-half the circumference of the nerve. With arterial silk sutures 3 and 4, Rotation of the mosquito clamps will permit the suture to be completed. 5, The completed suture. The tension suture is tied after all epineurial sutures are placed. Very gentle traction should be used in tying the tension suture to avoid damage to the nerve trunk.

Although voluminous literature of war injuries of the peripheral nerves accumulated in the years from 1919 to 1924 subsequent nerve injuries of civilian life have apparently received little attention in current medical literature despite their importance and the almost ideal conditions surrounding the treatment of such lesions.

In actual practice the treatment of nerve lesions resulting from transportation and industrial accidents in civilian life is far from satisfactory chiefly because of inexperience of those who attempt to carry out the primary treatment of the wound and the failure to make adequate use of physical therapy in the period of regeneration. In some cases tendons are sutured and the skin closed without investigation of the nerves in the field. One must conclude that the surgical treatment of lesions of peripheral nerves produced in civilian occupations has not benefited to the degree which should have been expected from the information gained in the study and treatment of nerve injuries in the first World War. A common peripheral nerve injury seen in private

practice is one just above the wrist involving the tendons and the ulnar or median or both of these nerves. This disabling injury is one of vast importance to the individual and too often the treatment of such a wound requiring as it does high operative skill, is entrusted to some inexperienced member of the house staff. Secondary operations not infrequently disclose suture of the median nerve to the palmaris longus or the ulnar to the flexor carpi ulnaris tendon. Such errors are deplorable.

The diagnosis of division of a nerve can be made unequivocally when a stab wound in the region of a nerve is followed by immediate paralysis of the nerve. If this proof of nerve division is kept in mind by those without special training in neurological surgery, divided nerves would not so often escape detection in the primary treatment of the wound but it seems too much to expect that the differentiation will be made between tendons and nerves by inexperienced operators. The associated division of the tendons in lacerations above the wrist may mask the symptoms of a nerve lesion and also seriously impair the

functional success of nerve suture. One often sees lacerations in the region of the parotid gland sutured without any effort having been made to find the facial nerve at the primary operation even though the patient was unable to close his eye or retract the corner of his mouth. Identification of the nerves at the time of primary treatment is much easier than it is later on when scar tissue has developed.

It is almost incredible that there should be so little unanimity of opinion as to just how much may be accomplished in the restoration of function of peripheral nerves under ideal conditions in the human being. The improvement of nerve function by direct suture, often described as satisfactory recovery, is a matter of common observation, but no criteria of recovery have as yet been formulated from which a clear impression can be obtained as to what permanent residual effects persist following nerve interruption. In other words, the terms which have been used to express the end-results of suture of divided nerves convey no uniform meaning. They are, therefore, of little value in estimating precisely the degree of functional recovery following nerve suture.

It is obvious that the final results of nerve suture are impaired by severe associated injuries or when suture is long delayed, but even in those cases in which the nerve lesion is the only important one, as in many cases of civilian practice, and the nerve is sutured at the primary treatment of the wound, there are certain residual effects of nerve interruption which are permanent. Inherent defects of regeneration of nerves have been discussed by Stopford, Cajal, Ford and Woodhall and others who have called attention to misdirection of downgrowing nerve fibers from the proximal segment. Accurate alignment and suture will not prevent straying of these fibers. Many regenerating fibers intended for one domain of the nerve field may find their way into another to the confusion of the normal nerve pattern. Because of the excessive number of regenerating axis cylinders, undoubtedly many will find appropriate pathways and reach their proper terminals, thereby restoring function of the nerve considerably.

Head, in his classical experiments on the cutaneous branch of the musculospiral nerve,

in his own arm, found persisting confusion in discriminative perception of certain types of peripheral stimuli.

Regeneration after anatomical division of the facial trunk is invariably followed by mass movements. The best explanation of this is that straying of regenerating fibers binds the muscles of expression into a functional unit incapable of the dissociation of action essential to emotional expression. It is very doubtful that re-education has any beneficial effect on such a permanent distortion of the nerve pattern, and it is highly probable that too much effort at re-education may make matters worse.

Perfect results in the treatment of peripheral nerve lesions may never be obtained, but this in no way should detract from the importance of continued study of the whole problem of nerve regeneration and search for the best methods of treatment.

An unrivaled opportunity for the advancement of knowledge of peripheral nerve injuries was lost after World War I through the failure to have the end-results of treatment of the Army cases assessed by those competent and interested in such lesions. After soldiers were discharged from the Peripheral Nerve Centers the subsequent care was assigned to other organizations. No satisfactory followup system was instituted. Valuable as was the information accumulated from the study of approximately 4,500 nerve injuries by competent personnel, the investigation lost most of its worth through the failure to determine the ultimate results of treatment. The writer must admit that with few exceptions, he received only impressions as to the results of the Cape May and Staten Island series. It is hoped that such an opportunity will not again be lost in dealing with nerve injuries in the present war, but that some effective plan for periodic surveys of these cases for at least 3 years after surgical treatment will be put into operation with a published final report as to the results of treatment.

The criteria of recovery of peripheral nerve injuries should be standardized with application of appropriate criteria to each individual nerve. The extent of functional disability following adequate surgical treatment of nerve

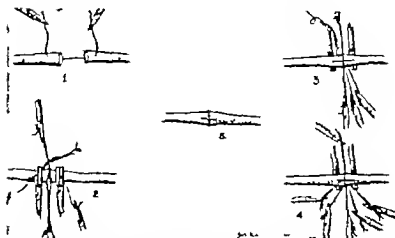


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TREATMENT OF WOUNDED IN THE COMBAT ZONE

DANIEL L. BORDEN, M D , F A C S , Colonel, M C , A U S , Washington, D C

UPON the walls of the Medical Field Service School at Carlisle Barracks, there is inscribed the basic purpose of the medical officer of the United States Army, "Conserve the Fighting Strength" Every effort of the medical department is bent, in time of war, toward the fulfillment of the principles expressed in this decree

War has been defined as a traumatic epidemic World War I was strictly a trench conflict where wounds were sustained in the presence of highly manured soil where gas gangrene was an ever present menace The present conflict involves motorized, mechanized warfare with mobile fighting where the principle of taking the doctor to the patient¹ and not the patient to the doctor is in vogue

Generally speaking, wounds in time of war come primarily from bullets which, in the present conflict, have a higher velocity with greater explosive action than we saw in the last conflict The high velocity bullet does not, as a rule, carry clothing into the human body but that bullet, in spite of its high velocity, is unstable if it meets with some obstruction and is apt to tumble or fall over in its course of flight within the body when its nose or point strikes bony resistance Various types of wounds can be expected from different types of bullets The German ammunition belt examined from captured German planes, has been shown to have five types of bullets placed in rotation on the belt in the following order ball ammunition, armor piercing bullet, armor piercing bullet with tracer, armor piercing bullet with incendiary, and explosive bullet This analysis of German ammunition as published by the British Army shows, immediately, the various types of bullets that are productive of wounds of war

Bursting shrapnel produce lacerated wounds that frequently carry particles of clothing in the course of their transit Also, bombs fracturing in the presence of buildings complicate the situation frequently by inflicting injuries from flying glass

The bayonet wound is, of course, rare as compared with that from bullets and bombs but we do have bayonet wounds from hand to hand fighting This is particularly true of the Japanese who train their troops to charge after throwing hand grenades The Japanese hand grenade, less powerful than the German or our grenade, stuns rather than destroys The Japanese soldier follows up the grenade attack with the bayonet Whether the wound be of bullet, shrapnel, or bayonet, it is considered infected

First aid to the wounded on the field is specific and limited in its scope It involves the use of a simple dry dressing, the control of hemorrhage, and the application of a tourniquet when necessary Stress is placed upon the importance of applying the tourniquet at the most distal point and making a note to that effect on the forehead of the soldier, or on his casualty card This is essential, for the man being returned to the rear may be unconscious and the presence of a tourniquet overlooked unless properly marked All chest wounds are closed as an emergency measure Except in head injuries, pain is controlled with large doses of morphine sulfate, care being taken to mark its administration on the casualty card of the injured soldier The old rule of splinting them where they lie applies in war surgery and a bayonet or gun stuck in the ground as a guide is an essential part of the first aid technique which makes the location of a wounded man apparent to the litter bearers

Evacuation of the wounded is based upon a general principle as illustrated in the enclosed diagram (Fig 1) It is recognized, and must be considered as paramount, that a basic

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¹Lull Brigadier General George F J Am M Ass. 1943 121 638

injuries depends on the nerve involved. It is generally believed and this has been the writer's experience that the musculospiral leads in the degree of recovery following suture. There are several reasons for this, one being that the nerve is predominantly motor, serves a coarse function and in its action as a stabilizer of the hand makes possible normal motor function of the median and ulnar.

The degree of permanent disability in the hand following division of the median or ulnar nerve will depend to a considerable extent on the occupation of the individual. Work not requiring discriminatory or fine movements of the hand may be done with little handicap while other occupations such as typing would be difficult if not impossible. Obvious limitations of functional recovery are imposed by changes which take place in the denervated muscles particularly in the intrinsic muscles of the hand. Atrophy of varying degree is an inevitable result of muscle denervation regardless of the time suture is done or measures instituted to prevent its development. This atrophy of hand muscles remains a permanent stigma of denervation following median and ulnar lesions. Periarticular fibrosis of the fingers, especially in severe partial lesions, frequently contributes to permanent impairment of function in the hand and mars the results of otherwise successful nerve suture.

Further progress in the treatment of peripheral nerve lesions will undoubtedly result from the experiences of the present war through prevention of infection which will

permit early exploration of the injured nerve by experienced neurological surgeons. Unless however precise criteria for evaluating the end-results of surgical treatment of lesions of individual nerves are formulated with systematic postoperative supervision, carried out by competent groups for at least 3 years, the results of operation on peripheral nerve lesions will remain largely a matter of impression rather than precise knowledge.

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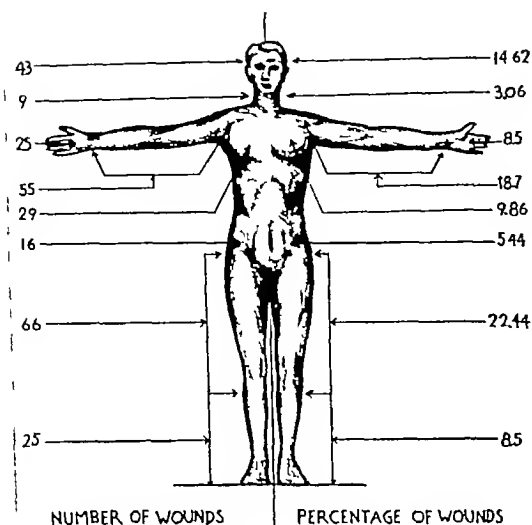


Fig. 2 Wound location chart for armored units in the Middle East.

It is an accepted fact that over 50 per cent of wounded men fall in the so called lightly wounded category. The division of men lightly wounded and those seriously wounded should be the responsibility of the senior surgeon. Lightly wounded men can be treated at the rate of approximately 10 cases per hour, whereas a single seriously wounded man requires at least 1 hour for his treatment. The senior surgeon must direct the priority or right-of-way for the disposition of injured men. Restoration to active service of as many men in the quickest possible time is imperative. More than this, time lag must be eliminated if possible, keeping in mind the so called golden 6 hour period. The guiding hand of the senior surgeon is an essential and necessary duty which is of the utmost importance.

The surgical approach to the wounded is preceded by x-ray examination which has, in recent years, been standardized by Colonel DeLorimer who has established, in field units, a biplane marker with an orientation device whereby the exact location of foreign objects within the body of the injured soldier are determined by triangulation. The English, in their statistical reports, state that they have removed 95 per cent of all foreign bodies in their gunshot and shrapnel cases.



Fig. 3 American modification of English method of evacuating injured men from tanks. Web belt slipped up under armpits.

Prior to surgery all wounds are cleansed with soap and water, every effort being made not to wash dirt into the wound. The use of nonirritating cleansing was popularized after Dunkirk when it was found that men remaining in salt water over long periods of time were found to have very little infection in their wounds. A wide incision including the deep fascial layers, débridement, removal of foreign bodies and fragments of clothing, with the dusting of crystal sulfanilamide and the application of vaseline gauze dressing completes the wound toilet. No suturing and the use of immobilization by casts in extensive soft tissue wounds as well as fractures is advocated. Casts should not be applied to men who are

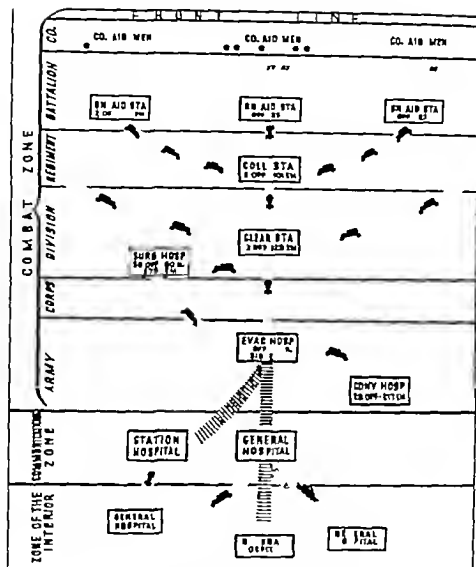


Fig. Chain of evacuation of wounded

scheme of evacuation is essential to act as a foundation for a compromise or changed plan in the presence of conflict. In other words, the ideal scheme of evacuation as worked out and demonstrated may have to be considerably modified in time of war. However the general principles of the ideal scheme must form the basic background for proper evacuation and treatment of the sick and wounded.

Treatment in the collecting, clearing, evacuation, or surgical stations must follow a thorough understood principle. The chief or senior surgeon of all of these units should act as liaison officer deciding the priority for operation, observation, evacuation, or treatment for shock of all wounded men. The proper classification as to the treatment of all wounded men is of the utmost importance.

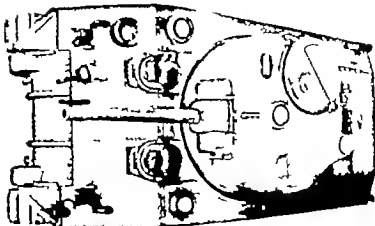


Fig. 4. American tank buttoned up demonstrating use of manholes and difficulties of evacuation for crowded.



Fig. 5. Disabled driver in the tank. Restriction of space makes evacuation of crowded extremely difficult.

to be transported by water where ships are subject to sinking by enemy action. A cast absorbs water when men are thrown into the sea and acts as an anchor. Therefore Thomas, Cramer wire and wooden splints should be used under these and appropriate circumstances.

Emergency early surgery of wounds involving injuries to nerves calls for the approximation of the nerves with a single suture to a subsequent repair. Bone fragments should be removed from compound fractures. All joint cavities should be closed the soft parts being

left open. Chest and head wounds call for débridement and closure.

As a matter of comparison, I quote from a letter written to my father during action on the Champaign sector in World War I:

'Our work usually goes on as follows. Before a drive is contemplated word reaches us through rumor or official notice. If either of these fail the barrage put down for several hours before an attack is so severe as to be unmistakable. With this warning everything is gotten ready. The wounded are gathered together by stretcher bearers and taken to the regimental aid stations. The function of these organizations is threefold: they examine every wound and control hemorrhage by first aid means, secondly, give a prophylactic dose of antitetanic serum, and lastly, and most important, divide the cases into transportable and nontransportable groups. Nontransportable cases are those requiring immediate attention and are sent at once to the field hospital by means of trucks, etc. Our field hospital (clearing station) receives wounds of the head, chest, abdomen, and serious extremity complications. Transportable cases are sent back to the evacuation hospital. Thus the field hospitals (clearing stations) get fewer and more serious cases whereas the evacuation hospitals do more work of a less serious character. Consequently the average mortality of a field hospital ranges about 10 per cent and the evacuation hospital, 5 per cent. This may be said to be an excellent average, in other words, a minimum.

'A case of the nontransportable group usually passes through the following stages. He is severely wounded and remains where he falls for a varying period of time. Exposure, lack of food and water, combined with pain and a rough ride, add the element of shock. These cases, if operated upon at once, invariably die, so that they are placed in a shock ward, stimulated, warmed up until their condition is improved and their chance of recovery enhanced.

'Head injuries are usually left alone except for débridement unless active hemorrhage is going on with signs of cerebral pressure.

'Chest wounds, which of their very nature are serious, are usually treated by simple closure. Machine gun wounds and small shrapnel penetrations are closed after débridement. These openings in the chest are closed at once at the first aid stations without anesthesia, for if allowed to remain open they produce the so called mediastinal flutter which, in turn, results in severe shock.

'Wounds of the abdomen of course call for immediate laparotomy and repair. Most cases will not permit of intestinal suture and an artificial (temporary) opening is usually advisable. Every case of intestinal anastomosis done in this hospital has resulted in death.

'Severe extremity wounds are treated by amputation or repair by débridement. The circular method of amputation is advised.

'War surgery permits of radical risks. Operating time is a most important element and forty minutes is the average maximum period allotted. Cases brought in here and kept on the table for over an hour will die.

'The average case with multiple small wounds shows much more shock than many of the seriously wounded.'

Although no statistics are as yet available all information points, in our present conflict, to a mortality rate under 3 per cent.

Burns are playing a large rôle in the traumatic epidemic of this war. Burns are undeniably wounds should be treated as such and we, as surgeons, should apply the fundamental medical principles of wounds to burns. The flash and blast burns produced by a wave of flame pressure from bombs and torpedoes are now well known. This pressure wave of fire occurring on shipboard, and frequently on land, is accompanied with such force that it often knocks men off their feet. Interesting enough, evidence of this is shown by the fact that the back of the scalp of sailors subjected to blast burns, is entirely bald where the hair and scalp has come in contact with the deck. The metal deck is so heated by the blast of an exploding bomb or torpedo that it will burn the unprotected parts of the body upon contact. Bomb blasts have both a pressure and a suction wave. Pressure from bombs produces pulmonary injury if an individual is close enough to receive a force of a hundred pounds per square inch. Carbon monoxide poisoning must always be considered a possibility in the close proximity of a bursting bomb.

A new type of burn has come into the picture in this war, namely, phosphorous burns. These burns are produced by incendiary bombs and tracer bullets. The burn gives a grayish white reaction which many times produces vapor arising from the wound. This type of wound is extremely painful, without blistering, has a prolonged period of healing, and tends to become septic.

The therapy of burns, together with the various protective and healing agents advocated, indicates only too well that the final word has not been said in the treatment of this condition. All agree with the theory of treating the patient first and the burn second. There is no controversy in the use of morphine.

to control pain plasma in the presence of shock, and oxygen, especially in blast burns to combat anoxemia. In the local treatment the fundamental principle of considering a burn a wound has become universally accepted. The use of masks, rubber gloves, and sterile gowns by nurses and doctors in dressing burns is imperative to guard against infection. Debridement with soap and water under morphine sedation unquestionably gives the best result.

Controversy still exists in the use of the tanning methods formerly in vogue before the war began and which received tremendous impetus at the Pearl Harbor incident. An eschar artificially produced is known to injure the epithelium of the skin and frequently nurtures infection with disastrous results, especially to the flexor surfaces of the body, the face and the genitalia. On the field of battle when tannic acid is applied locally to men later transferred from the forward positions to the zone of interior infection has frequently developed and spread under the eschar producing a serious and irreparable final outcome. The constrictive effect of the tanning eschar often results in the loss of tissue of the nose and the top of the ears. It also frequently interferes with the circulation of the extremities.

It is a reported possibility that tanning may have a toxic effect on the liver but the final constrictive effect of the tanning processes causing further injury to the epithelium plus the danger of infection which results in contractures, has condemned this method of procedure so far as military surgery is concerned. The same rule applied to other tanning methods such as the triple dyes and Fickrell solution.

Because of this entire situation the Army has published a War Department directive advising the use of boric acid ointment or sterile vaseline supported by the pressure bandage. This method of treating burns was popularized during the recent Boston fire catastrophe and since has proved to be most effective. In time of war simple boric acid or sterile vaseline gauze may be applied with pressure bandages and allowed to remain on for a period of 10 days before they are re-

moved. The sulfa drugs should be administered orally or intravenously in association with the pressure bandage method of treatment. In this connection, it has been demonstrated that the serum removed from burn blisters contains the same amount of sulfa concentration as the circulating blood. Therefore, it is quite apparent that the controlling influence of the sulfa drug is taken to the site of the burn through the blood stream whether the drug is given by mouth or applied locally. The use of sulfa drugs incorporated in an oil base of 6 per cent sulfanilamide or cold cream and lanolin makes an ideal ointment for the local application to burns and has received excellent results in the hands of those men who have used this type of treatment.

Equally good results can be obtained by the application of a simple boric acid ointment, vaseline or sulfa incorporated oil base dressing to the face with or without pressure bandages. Although it is advisable to debride contaminated burns at the clearing stations, debridement can be eliminated and the ointment applied immediately to the burned surface. Men, when it is possible, should be encouraged to return to duty with instructions to have the burn redressed in a period of about 10 days. Redressing is best done under water so as to eliminate pain.

Finally, in its definitive treatment, teams of men specially trained in the care of burns should be established. Burned soldiers are helpless, cannot eat or dress themselves, and need a great deal of understanding and consideration. It has been noted that the skin surfaces, upon healing, are especially sensitive and that men will go through the wards holding their hands up in the air to avoid irritation. To help this situation olive oil can be applied to the skin. It is also very useful to fit these patients with gloves to protect the sensitive skin until it becomes hardened to the external atmosphere. Obviously early skin graft is indicated in all third degree burns.

Burns involving the mucous membrane of the nasal pharyngeal surfaces frequently require tracheotomy in their treatment. This should be borne in mind in addition to the use of oxygen for this type of burn.

More recently the use of this great compound has been advocated in the treatment of burns in the hands of first aid.

The treatment of the phosphorus burn calls for immediate emergency treatment in all three degrees of available. Application of a few drops of water will dilute the phosphorus and prevent further absorption. The phosphorus should be removed with forceps, and the burn should be covered with a sterile dressing. The phosphorus should be removed with forceps, and the burn should be covered with a sterile dressing. The phosphorus should be removed with forceps, and the burn should be covered with a sterile dressing.

The breech loading of this weapon is a
organization but a technical one. It has been
may give rise to the fact that the machine
subject to all the hazards incident to mobile
warfare. The tank with its armor protected
body is a potential force concentrated in a
control. Its most effective is concentrated in a
hastening, etc., and its armor is filled with a com-
and stress etc. has no structure to heat and
cold. Experience has shown in desert fighting
that tank temperature is made bearable by the
circulation of air within the tank caused by
the revolving engine etc. This accounts for
the remarkable situation that has been im-
demonstrated in the British fighting where the
cases of heat prostration have been reported in
tank divisions. A tank even though it is
stranded is entirely bearable as long as the
air is kept in motion by a running engine.
Men afflicted with claustrophobia find a
place in tank warfare. Tanks are now built
are now built.

Men afflicted with claustrophobia have no place in rail travel. A closed unit, doors are now built in the floors of rails to provide emergency exits. These escape doors in the floor, plus the normal avenues of escape through the manholes provide ways for immediate evacuation.

Men who suffer from dust allergy are chim-
nerated before entering the war zones. Tanks
create a great deal of dust not only with their
interpillar tracks but also from gun bursts.
Our older tanks that were bolted
proved to be a definite
improving the tank

Our older tanks that were bolted together proved to be a definite hazard. A missile striking the tank but not penetrating its armor, transmitted its force to such a degree that the bolts would be broken loose inside.

the tank to become secondary projectile
Welding has taken the place of bolts and has
streamlined our tanks so that angles and flat
surfaces have been partly well eliminated.
This rounding or streamlining of the tank has
at a decreased production of projectile
rather than per cent of its surface for their
direct contact.

A large amount of heat is
lost by a tank.

A large amount of heat and force is converted for a projectile striking a tool. This energy is transmitted directly and may result in chipping or crushing the tool within the tool, burning or igniting the tool and it may even ignite the material.

... have even written recommendable material for evacuation of your dog from tank in time of war. A definite hazard although this usually is not a serious one it might at first appear. I am in luck have chosen that I don't expect of tank crews evacuate themselves. It is an amazing fact that a severely injured man will often get out of a disabled tank either alone or with the help of his companion. The fear of enemy danger is so great that mental reaction overcomes physical disability. This leaves approximately 10 per cent of the crew to be evacuated by the medical department a problem which frequently involves great difficulty.

Crews in evacuating tank should protect themselves although

to involve great difficulty must seek
ground protection rather than tank protection
although the human reaction is to seek shelter
behind some object. The tank is always a
target for enemy fire. It will be fired upon
even though disabled. Upon striking the tank
projectiles frequently fracture and their frag-
mented parts are thrown in every direction.
The English have found that at least one third
of tank crews are injured when caught near
their tanks. Therefore experience has shown
that ground protection is far safer than tank
protection.

In the presence of enemy tanks
disabled wounded and
imprisoned

In the presence of enemy fire evacuation of disabled wounded men from tanks becomes imperative and necessarily must be done as quickly as possible. It is pretty well agreed that the quickest and surest way of getting a wounded man out of a tank in a hurry is to draw a half hitch around his feet and extract him by the inverse method. Many modifications and various methods for the evacuation of wounded have been established by both the

British and American Armies To facilitate evacuation and to control pain morphine is ready to use "syringes" is supplied to all members of our tank crews. The English go a step further when evacuating seriously wounded soldiers by using chloroform incorporated in gauze to eliminate the problem of pain and discomfort.

Modern warfare with its quick, brutal destruction on a mass scale involving speed, force and endurance has called upon the military surgeon to use his initiative and resourcefulness in a resilient aggressive manner. Mobile warfare has been applied to the evacuation of the sick and wounded so that the air plane as well as the motor vehicle is responsible for their rapid transportation to hospital centers. This, with early treatment, plasma and the sulfa drugs, in part accounts for the

remarkably low mortality rate of the present war. In a former paper I stated and still maintain that the basic reasons for the success of the medical department of the United States Army has been superior leadership with the preliminary medical training that has qualified men through the various specialty boards, the American College of Surgeons, and the American College of Physicians, to do excellent surgery. After all is said and done good surgery based on sound medical principles is responsible to a larger degree for the record that has been made by the medical department of the United States Army. As never before in the history of man, the medical department is conserving the fighting strength."

¹From civilian practice to military service. *Med. Ann. Dist. Columbia*, 1944, 20.

CERVICAL LYMPH NODE METASTASIS AS THE FIRST SYMPTOM OF CANCER

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THE subject of cervical metastatic cancer is ordinarily considered of significance from the standpoints of treatment and prognosis alone, since the average physician regards metastasis as a secondary or late symptom found only in association with a readily demonstrable primary growth. This view also prevails in the medical literature on cancer of the mouth and pharynx. It is not generally realized that cervical metastasis frequently occurs as the initial, and for a time, the only symptom from an otherwise silent primary malignant tumor in the upper respiratory or alimentary tracts or, rarely, from a primary growth in some viscus below the clavicle. Such silent primary lesions are often not suspected or at least not found when the patients first seek medical advice because of cervical tumors (cervical lymph node metastases). Even after repeated and thorough examinations, the primary growth may not become evident for months or even years, and it is certain that many persons die of widely disseminated cancer undiagnosed as regards the origin of the growth.

Unless the nature of this phenomenon is clearly understood, namely that the symptoms from the primary and secondary lesions are sometimes reversed chronologically, then the diagnosis may be missed, or at least delayed until the malignant growth has become widely disseminated and incurable. In other instances, the metastases in cervical lymph nodes may be considered erroneously as the primary site of origin of the growth and consequently such entirely inadequate diagnoses as "carcinoma of the neck" and "sarcoma of the neck" are made.

The cancer patient or his family naturally are most concerned with the immediate symptoms which in many instances (especially in the later stages) may be the result of metastasis (pulmonary, osseous, lymph nodal, etc.), therefore, in a given case, the layman is likely to think of cancer as affecting the lungs, the bones, or some other structure, and to him it appears to be of little significance and somewhat beside the point that the disease may have originated specifically in some such area as the tonsil, the breast, or the stomach. Strangely enough, many physicians have the same lay point of view. Since all methods of treatment (surgery and radiation) at present are strictly local in their application, it should be plain that cure is not possible unless the location of the primary growth is discovered. The purpose of the present report is to discuss this phenomenon (cervical lymph node metastasis appearing as the initial symptom of cancer) from the standpoints of incidence, site of the silent primary lesion and clinical course, with special reference to differential diagnosis. The data used in this study were obtained from a review of about 3,800 consecutive cases, all observed at the Memorial Hospital from 1933 to 1937. The character of this clinical material is shown in Table I.

In Table II are listed the cases of 218 patients who at first complained only of cervical tumors which were subsequently proved to be carcinomatous, and therefore probably metastatic.

One is often struck by the fact that some physicians (usually not greatly interested in cancer) refer to patients as "suffering from or as having died of cancer of the lung or of the pelvis" etc. and subsequently add as a relatively unimportant afterthought that the breast or uterus was removed for a growth at some previous time. Similarly, when investigating the cause of death in untraced cancer patients it is often found that death certificates have been filed bearing such diagnoses as "carcinoma of the lung" or "the pelvis" or "the liver" etc. when as a matter of fact the patients in question when last seen were known to be suffering from widely disseminated cancer originating in some such site as the breast, the tongue, or tonsil. The actual proportion of such erroneous diagnoses in the recording of cancer deaths is undoubtedly large enough to vitiate the generally accepted figures as to the anatomic distribution of primary malignant tumors. As the result many dubious conclusions are drawn by some public health authorities. Biometricians and medical writers. For example, certain writers in recent years have announced in all seriousness that lung cancer is increasing at an alarming rate. One cannot help but suspect that this increase may be due at least in part to the manner of reporting the cause of death in cases of pulmonary metastases from various primary growths.

From the Head and Neck Service, Memorial Hospital, New York

TABLE I.—SUMMARY OF THE TOTAL CLINICAL MATERIAL USED IN THE PRESENT STUDY OF INITIALLY SYMPTOMATIC CERVICAL METASTASIS FROM SILENT PRIMARY MALIGNANT TUMORS

Anatomic site of the primary cancer	No.	Per cent	Total number of cases
Mouth and pharynx			567
Cervical metastasis the first symptom in	45	7.8	
Thyroid			80
Cervical metastasis the first symptom in	7	8.8	
Salivary glands			14
Cervical metastasis the first symptom in			
Various anatomic sites below the level of the clavicle			744
Cervical metastasis the first symptom in		6	
Breast, 3 in 100, or 3% stomach, in 200 lungs, in 100 esophagus, in 100 pancreas, in 74 or 7% kidney and adrenal, 4 in 70 or 5.7%			
Miscellaneous cases of initially symptomatic cervical carcinoma			33
A primary error found	47		
Lived 5 years and therefore probably bronchiogenic carcinoma	8		
Total number of cases reviewed			1,860

*Early cervical metastasis associated with slight although definite early symptoms of primary lesion were found as follows: Lung 10 (2%), Stomach 1 (2%), Esophagus 1 (2%)

static from silent primary lesions. In 163 of these cases, the silent primary lesions were eventually discovered and proved by biopsy while 55 cases had to be considered as inconclusive since no primary lesions were ever discovered. It should be noted that this clinical material is not uniform in character and significance for example at one extreme are found the cases of those patients who sought medical advice complaining only of cervical tumors (enlarged cervical lymph nodes) while disregarding slight symptoms of a primary lesion. Such disregarded symptoms can sometimes be elicited and the primary growth immediately found by the examining physician. At the other extreme are the cases of those patients complaining only of cervical tumors in whom small primary lesions were discovered only after repeated and careful examinations and a delay of from 1 to 2 years.

Definition. The *sine qua non* that lymph nodes are diseased from any cause is an in-

TABLE II.—TIME AND METHOD OF DISCOVERY OF THE LOCATION OF INITIALLY SILENT PRIMARY LESIONS IN 218 CASES IN WHICH CERVICAL METASTASIS APPEARED AS THE FIRST SYMPTOM OF CANCER

	No.	Per cent	Total
Determinate cases (primary lesions eventually found in all)			143
Primary lesion discovered by referring physician before admission to Memorial Hospital	57	31	
Primary lesion discovered first in the outpatient office of the Memorial Hospital	58	34	
Primary lesions not found by referring physician or in the admitting office of the Memorial Hospital and discovered first in the Head and Neck Clinic within 3-4 examinations	34	23	
Primary lesion discovered only after repeated examinations in the Head and Neck Clinic and delay of 3-4 months	6	9	
Indeterminate cases (biopsy from the cervical nodes revealed squamous or epidermoid carcinoma, but no primary as ever found)			33
Total number of cases			176

*The term "referring physician" does not necessarily mean that the patient had been seen by only one doctor before being referred to the Memorial Hospital. In many cases, usually depending upon the severity of the primary tumor, the patient had been seen by one, two, three, or even four doctors before being referred to the Memorial Hospital.

crease in size and it is only when definite enlargement has taken place that such other characteristics as consistency, tenderness, mobility or contour can be of much diagnostic significance. In a discussion such as the present one it would be useful therefore if one could specify the normal size of each of the various lymph nodes (or at least of the main nodes) so as to permit a definition of what should be considered abnormal enlargement. Unfortunately, no exact rule can be given in this regard. Consequently before proceeding further it is necessary to define what is usually understood by the loose terms "lymphadenopathy" and "enlargement of lymph nodes."

For practical purposes it may be assumed that when a physician states that lymph nodes are enlarged he intends to indicate that they are abnormal, that is to say diseased, or at least that, being uncertain, he advisedly uses an ambiguous term. Contrary to an apparently widely accepted belief lymph nodes are not necessarily enlarged

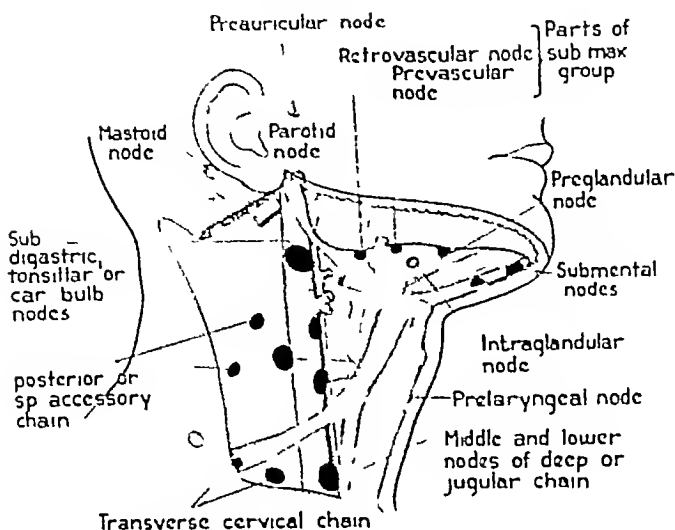


Fig 1 Diagram of the most frequent positions of cervical lymph node metastases with the most likely sites of the primary lesions causing them

simply because they are palpable¹ In the normal cervical lymphatics, the nodes vary in size from less than a millimeter up to 1.5 centimeters or occasionally even 2 centimeters in diameter. The larger normal cervical lymph nodes (1 to 2 cm in diameter and therefore readily palpable) are found, however, only in certain locations, namely, the upper deep cervical (subdigastric) and the prevascular and retrovascular submaxillary areas (Fig 1). The occurrence of lymph nodes larger than 1 centimeter in diameter in other regions of the neck can usually be considered abnormal. It is fortunate, however, that for the present discussion, no exact line of differentiation in size between normal and abnormal nodes is necessary since in the cases included in this study, the nodes when in-

volved by metastases were invariably at least 3 centimeters and usually 4 centimeters in diameter at the time when the patients were first admitted.

A distinction should be made also between enlargement of cervical lymph nodes and enlargement (or other abnormality) of the true cervical glands (submaxillary salivary, sublingual salivary, parotid salivary, thyroid, etc.). Abnormalities of these true glands have no relation to the subject under discussion except from the viewpoint of differential diagnosis. It will be assumed, furthermore, that cervical lymph node enlargement will not be confused with other cervical tumors, either benign or malignant, such as branchiogenic and thyroglossal cysts, lipomas, thyroid adenomas, soft part sarcomas, and similar conditions.

INCIDENCE OF CERVICAL METASTASIS AS A FIRST SYMPTOM OF CANCER

A survey of the histories of several hundred cases in our clinic as listed in Table I reveals that the appearance of a cervical swelling or mass (metastasis) was the first and for a time the only symptom noted by the patient in about 8 per cent of all cases of cancer of the mouth, pharynx, and thyroid. In primary

¹In clinics where large numbers of patients with mouth and pharyngeal cancer are followed, it is clearly recognized that certain lymph nodes of the neck are palpable in the majority of normal persons. For this reason the palpability alone of lymph nodes either in normal persons or in those who have cancer should not be considered as necessarily indicating metastasis. Unfortunately, there is a widespread belief that all palpable lymph nodes are abnormal as for instance in some texts on physical diagnosis one finds such misleading phrases as "lymph nodes enlarged to 1 centimeter in diameter without any further qualification." One must, therefore, conclude that the author erroneously considers any lymph node 1 centimeter in diameter wherever situated to be abnormal or possibly being uncertain he prefers to leave the decision to the reader. Similarly in some publications on intraoral cancer the sole fact that lymph nodes are palpable is obviously considered a presumptive sign of metastatic cancer. In such publications the subject of cervical metastasis is sometimes disposed of by giving the percentage of cases in which the nodes (usually referred to as "glands") are either palpable or not palpable.

TABLE III — SITE OF THE EVENTUALLY DISCOVERED PRIMARY LESION ABOVE THE LEVEL OF THE CLAVICLE IN 152 CASES IN WHICH THE FIRST SYMPTOM WAS THE PRESSENCE OF A CERVICAL TUMOR (LATER PROVED TO BE CARCINOMATOUS)

(935-937)		
Site in which primary lesion was eventually discovered	Number of Cases	Per cent of total
Tonsil	35	3
Nasopharynx	33	23
Tongue	20	9
Extrinsic larynx		4
Floor of mouth		7
Pharynx	9	6
Thyroid	7	5
Palate	4	3
Paranasal sinuses		6
Gums		6
Intrinsic larynx		6
Total number of cases	5	00

The discrepancy between the number of cases listed in this table (5) and that listed in Table I (163) is accounted for by the cases with primary lesions below the level of the clavicle as listed in Table I.

growths below the clavicle metastasis rarely occurred as a first symptom with the exception of the kidney and adrenal (5.7 per cent) and pancreas (2.7 per cent). Probably it is not generally realized that initially symptomatic cervical metastasis occurs so frequently from a silent primary lesion; this is especially true in cases of cancer of the mouth and pharynx for on the average 1 in about 2 patients so afflicted first seeks medical advice because of a cervical mass.

Table II gives the time of discovery of the primary lesions above the level of the clavicle. In 163 cases in which patients complained only of enlarged cervical nodes. It will be seen that on admission to the clinic at Memorial Hospital the silent primary lesions had been discovered already by the referring physicians in about one third of the cases. In another third the primary lesions were found in the admitting office at the time of the first visit while in the remaining third the location of the primary growths was discovered only after a delay of several weeks or months. In addition to the above mentioned there are listed in Table II 55 cases of patients who complained only of cervical tumors (proved histologically to be either squamous or epidermoid carcinoma) in whom no primary lesions were ever found. In a part of the latter group the follow up was inadequate and it

is possible that in some of these the primary growths became obvious before death. In others regularly followed after treatment to the cervical tumor no primary lesions were ever demonstrated up to the time of death or after a follow up of 5 or more years (Table VI).

Topographic distribution of silent primary lesions in the mouth and pharynx. In Table III are listed the sites at which the silent primary lesions above the level of the clavicle were discovered in 152 cases of patients complaining only of cervical masses. The primary growths, if above the level of the clavicle are most often found in the tonsil or nasopharynx, followed next in the order of frequency by the tongue, extrinsic larynx, floor of the mouth, palate and paranasal sinuses. While it is plain to see why a growth in the nasopharynx, tonsil or base of the tongue should remain symptomless for a time it is curious that growths in such tactually sensitive areas as the floor of the mouth or palate should be frequently overlooked by both the patients and the first examining physicians.

The following data are from previously published studies on several anatomic forms of cancer from the Head and Neck Service of the Memorial Hospital with reference to the percentages in which cervical masses appeared as a first symptom (10, 12, 14, 15, 16): nasopharynx, 50 per cent; tonsil, 33 per cent; base of tongue, 30 per cent; floor of mouth, 10 per cent; gums, 4 per cent.

Cervical metastasis as a first symptom in primary cancer below the level of the clavicle.

Cervical lymph node metastasis may occur as part of the wide dissemination in the later stages of cancer from a primary growth in any part of the body. The occurrence of a supraclavicular mass usually on the left and sometimes referred to as the *signal node* has long been considered of particular significance as suggesting the presence of a silent primary malignant growth below the level of the clavicle.

This concept dates from Trueman (17) in 1893, in which he reported seven cases in which he found cervical masses in the lower part, usually on the left, in association with malignant tumors of the abdomen, among the various masses between these cervical masses he found only the metastases which had developed from tumor emboli by way of the thoracic duct. It now seems that many of these supraclavicular masses on the left are not actually lymph nodes but rather are part of the thoracic duct or its branches. The thoracic duct of the left has been shown the distribution of the lymphatics in some detail.

From the standpoint of the present study, it is important to distinguish between those rare cervical lymph node enlargements which occur as the first and only symptom and those (more common), though occurring early in the course of the disease are nevertheless preceded by definite though slight or ill-defined symptoms of the primary growth below the level of the clavicle. One must also distinguish those cases of cervical metastatic cancer which occur several years following the removal or treatment of a primary growth below the level of the clavicle. In such cases, the past history of the primary tumor is sometimes not readily elicited, or in any case, the probability of any causal relationship may at first seem remote.¹

In the course of this study, we reviewed a series of about 1,700 cases of cancer at various primary sites below the level of the clavicle as listed in Table I and found that cervical lymph node metastases rarely occur as the first and only symptom from a primary growth below the level of the clavicle (11 in 1,744 cases, or 0.6 per cent). In this series, nevertheless, it occurred as an early, but not first, symptom in an additional 18 of 1,744 cases (1.0 per cent).

In the 163 cases of initially symptomatic cervical metastases, as discussed in this report, the primary growth was below the clavicle in only 7 cases or 3 per cent.

It seems to us that both the diagnostic and the clinical significance of the so called *signal node* has been somewhat overemphasized. In personal communications, Dr. Frank Adair of the breast service and Dr. George Pack of the gastric service of the Memorial Hospital stated that they considered cervical metastasis of little clinical significance in either breast or gastric cancer since this complication rarely occurred as an early symptom. Dr. Lloyd Craver of the admitting department of the Memorial Hospital also in a personal communication stated that although he

¹Several examples of such a complication have been noted at Memorial Hospital as for example a case of cancer of the cervix in which treatment was followed by apparent freedom of disease for 10 years when an enlarged neck node appeared which proved to be histologically identical with the uterine tumor. In a second case an orchidectomy was performed for embryonal carcinoma of the testicle and the next clinical evidence of the disease was the appearance of a cervical lymph node metastasis 2.5 years later. In several cases of late dissemination was the trunk and extremities the first evidence of late dissemination was the appearance of a cervical mass. Other similar observations have been made at the Memorial Hospital in cases of cancer of the breast, lung, stomach, kidney and pancreas.

considered the signal node of "important diagnostic significance," nevertheless he conceded that "in most of the cases there are associated symptoms indicating the site of the primary lesion." It seems fair, therefore, to conclude that the *signal node* is sometimes an early but rarely an initial symptom. *B. M.*

SYMPTOMS AND CLINICAL COURSE OF CANCER APPEARING FIRST IN THE FORM OF CERVICAL METASTASIS

It is a common observation that malignant tumors, either primary or metastatic, if situated so as not to press upon or deeply invade any vital structure may for a time cause no subjective symptoms, such as discomfort or dysfunction. This is particularly true of cervical lymph node metastases, which may reach a diameter of 7 to 8 centimeters or even larger without producing any objective symptoms other than visibility and palpability. It appears difficult, nevertheless, for the average layman and even for some physicians to realize that a disease as malignant as cancer can exist anywhere without causing pain or discomfort. For this reason, malignant cervical tumors unaccompanied by subjective symptoms (pain, tenderness, disability) are commonly first considered to be inflammatory in origin, especially when the enlargement has been rapid.

Discovery of cervical lymph node metastases by the patient. When cervical lymph node metastasis occurs from a silent primary lesion, the patient sometimes states that the swelling (3 to 5 cm. in diameter) appeared suddenly at a specified time and that he is certain it was not present the day before. Cervical tumors of this size histologically proved to be squamous or epidermoid carcinoma must, of course, have been present for several weeks or even months. Such cases demonstrate the frequent unreliability of patients' histories when the symptoms are purely objective. Since there are seldom any subjective symptoms of the cervical swelling, the patient almost always delays seeking medical advice. After the tumor has once been noted, the patient then pays a little closer attention to it and the observation that there has been a *steady increase in size* is the usual reason for his finally seeking a medical consultation. In

TABLE IV—SYMPTOMATOLOGY IN 218 CASES IN WHICH A CERVICAL TUMOR (LATER PROVED TO BE CARCINOMATOUS) WAS THE FIRST AND FOR A TIME THE ONLY COMPLAINT

	Number of cases	Per cent
Group I	99	45
In Group I, the visible and palpable presence of cervical tumor was the only complaint. No associated symptoms of primary lesion was elicited by the first examining physician. Primary lesion was eventually found in all these cases.		
Group II	64	30
In Group II, the visible and palpable presence of cervical tumor was the only complaint, but the presence of other slight symptoms was elicited by the examining physician and primary cancer at another site demonstrated on physical examination.		
Group III	55	25
In group III, the visible and palpable presence of cervical tumor was the only complaint. No primary cancer elsewhere was ever found.		
Total number of cases	218	100

our series, only about 10 per cent of these patients had consulted a doctor within the first week after noting the cervical mass. The average delay in seeking medical advice was 6 weeks.

Disregarded initial or early symptoms of the primary lesion. The patient seeking medical advice because of a painless cervical mass is not likely to mention voluntarily any apparently (to him) unrelated symptoms. That such pertinent symptoms are actually present and can be elicited on questioning in about 30 per cent of all patients complaining only of cervical tumors is shown in Table IV. Some examples of frequently disregarded symptoms are slight though persistent deafness or "stiffness" in one ear slight soreness of the throat or mild dysphagia which the patient does not consider of any particular importance, inasmuch as there is no marked distress or disability.

If the investigation is pursued a little further in an attempt to learn why the slight symptoms of primary lesions are so often disregarded, it is sometimes found that the patient is suffering from a number of the infirmities of old age and to him it seems more reasonable to deal with one thing at a time than to discover these disregarded symptoms of the primary lesion when the patient seeks medical

advice is ordinarily due to the fact that no inquiry is made by the examining physician.

Eventual discovery of the primary lesion. If the examining physician is well informed as to the symptomatology of cancer he will make careful inquiry as to any symptoms which might suggest the location of a primary lesion in all cases of cervical tumors. If no clue appears following such questioning he will proceed with an examination of the mouth and of the oral and nasal pharynxes. The discovery of the primary lesion (if present) is not difficult in most cases. A review of our data suggests that a failure to discover the primary growth is due in most instances to a failure to make any examination whatsoever of the mouth or pharynx, or at least a failure to employ adequate instruments and apparatus (headlight throat mirror etc.)

In Table II are listed the cases of initially symptomatic cervical metastasis and the time and place of the discovery of the silent primary growth. It is to be noted that in 163 cases of the present series, the manner of discovery of the silent tumors was about as follows: In one-third of the cases by a referring physician in an additional one-third of the cases by an admitting physician of the hospital in the remaining one third of the cases, the majority of the silent primary growths were discovered only after examination by the attending staff of the head and neck service. It should be noted further that in 55 additional cases primary lesions other than the cervical tumors were never found, either up to the time of death or after at least a 5 year period of observation. It should be stated that the failure by the referring physician to discover the silent primaries in these cases is apparently due more often to failure to look for them rather than to the obscurity of the lesions themselves.

Typical example of failure to elicit symptoms of a primary lesion shown in the following case. A male, aged 65, applied to the surgical and gynecological department of a large metropolitan hospital complaining of lump in the neck. He was immediately operated upon in the neck, parotid gland, the mass excised, and wedge-shaped specimen removed. When the histologic report was returned no carcinoma was found. He was referred to the Memorial Hospital with diagnosis of carcinoma of the neck. On subsequent (short) primary examinations of the mouth revealed an advanced, growing lesion. Contrary to discovery of the source of the cancer. On further questioning the patient admitted that he knew his mouth was sore, but that he thought the cancer was bad teeth from which he had been suffering for many years. It plus that the patient's primary lesion had made no attempt to do any symptoms or pain in the mouth, but any examination before proceeding with biopsy of the cervical mass.

The subject of silent primary tumors in the nasopharynx deserves particular attention. As has previously been described from our clinic (12), the most frequent initial symptom in nasopharyngeal cancer is cervical metastasis (in over 50 per cent of all cases). In the series of cases analyzed for this report, the silent primary lesions in the nasopharynx were discovered first by one of the attending staff of the head and neck service in about 65 per cent of all the cases, that is, in 65 per cent of the cases, the primary lesions were missed by both the referring physician and the admitting physician. The reason that so large a proportion of these silent growths were at first missed is that this anatomic site requires special apparatus (headlight, throat mirror, soft palate retractor), and a skill acquired only after considerable experience. Such experience engenders the conviction that if the primary lesion is not found elsewhere, particular attention should be paid to the nasopharynx. In the majority of such cases, the primary lesion appears as a fungating, granular outgrowth (1.5 to 2 cm in diameter or more) at the junction of the posterior and lateral nasopharyngeal walls (fossa of Rosenmueller).

Anatomically, the nasopharyngeal cavity is wider than the air passages immediately distal and proximal so that tumors in this region do not cause any obstruction to respiration until they reach a size of 5 to 6 centimeters in diameter. Nevertheless, most growths of the nasopharynx can readily be visualized on the first visit by mirror examination through the open mouth with the free edge of the soft palate retracted forward. In this manner, the whole nasopharynx can be visualized, by means of binocular vision. Far too often, the discovery of lesions in the upper respiratory and alimentary tract is missed because the examiner places too much dependence on the strictly limited field of monocular vision, permitted by complicated endoscopic and periscope instruments (antrascopes, nasopharyngoscope, laryngoscope, etc.).

In the extrinsic larynx or pharyngeal walls, the silent primary lesion can usually be demonstrated by mirror examination. In these regions, there is less tendency for the primary growth to remain so small as to be

undetected by the naked eye than in the nasopharynx, the base of the tongue, the tonsil, the floor of the mouth, etc. Lesions in the pyriform sinuses or postcricoid region cannot always be demonstrated clearly by mirror examination alone, though in the average case, asymmetry of the walls of the pyriform sinuses or of the postarytenoid region can be detected, suggesting that an endoscopic examination at a little lower level is in order.

The number of cases of silent growths below the clavicle with initially symptomatic cervical metastasis, is too small to permit of any definite conclusions (11), but it is noteworthy that in both of the 2 cases of cancer of the pancreas listed in Table I, the primary lesions were discovered late in the course of the disease and only after repeated examinations.

In Table II are also listed a total of 16 cases in which the primary lesions were not discovered until after repeated examinations and some delay, varying from 1 month to 54 months. Superficially considered, this delay might be disposed of by concluding that obvious primary lesions were repeatedly missed by the examining surgeons in our clinic, but we feel certain that such was not the case. These 16 patients were examined repeatedly by various members of the attending staff of the head and neck service with the specific purpose of locating the suspected primary lesions. In all of these cases, the primary growths, when eventually discovered, were only a few millimeters in diameter. In these patients, silent primary lesions were discovered only after 1 to 54 months and after 4 to 55 examinations conducted by four or five different attending surgeons of the head and neck staff. In such cases, it is the routine practice to make at least 5 or 6 complete examinations of the mouth and pharynx during the first month and at least one examination per month thereafter until a period of at least 5 years is passed or the primary growth is discovered.

These observations prove, at least to our own satisfaction, that a primary lesion may remain so small as to be unrecognizable to the naked eye, that is, it may produce no significant alteration in the surface contour

TABLE V—CLINICAL COURSE AND END-RESULTS
IN 55 CASES OF CARCINOMATOUS CERVICAL
TUMORS IN WHICH NO PRIMARY LESION
WAS EVER FOUND

	Number of cases	Per cent
Alive and well after 5 years or more and therefore fulfilling the criteria of bron- chiogenic carcinoma	8	5
Dead of cancer or followed for less than 5 years without the discovery of pri- mary lesion and therefore diagnosed as "Cervical Metastatic Cancer—N. Pri- mary Found	47	85
Total number of cases	55	90

of the mucosa nor any noticeable ulceration, but may nevertheless metastasize so as to produce bulky cervical tumors, sometimes 4 to 5 centimeters in diameter. Such phenomena lead to interesting speculations as to the nature of the factors which determine the rate of growth in malignant tumors. For instance why do certain primary malignant tumors behave so much like normal tissues in that they respond to growth control influences and remain microscopic in size yet nevertheless possess an uninhibited capacity to metastasize? Furthermore once having metastasized why do the same growth control factors likewise not inhibit the rapid and bulky growth of the metastases? In these cases, one must assume that there are differences in the biologic conditions at the primary and secondary sites of growth and that in these cases, at least the growth control function is not necessarily systemic, but local and possibly neurotropic.

In Table V. It will be seen that in our series, 47 patients with histologically proved carcinomatous cervical tumors died of their disease or were lost track of without the discovery of any primary lesions. The question naturally arises as to whether these cases all represent bronchiogenic cancer or primary lymph node cancer or whether primary growths of the mucous membrane existed but remained small and silent up to the time of death or appeared after the patients were lost to follow-up.

After a consideration of all known facts, we have decided upon the following practical method for the classification of cases of cervical epithelial cancer in which no primary

lesion is ever discovered. (1) If the patient has survived 5 years or more following treatment of a squamous or epidermoid cervical carcinoma of the soft parts of the neck without the discovery of a primary lesion, the probable though not absolutely proved diagnosis is "branchiogenic carcinoma." (2) If the histologic examination of such cervical tumors revealed transitional cell carcinoma or lymphoepithelioma and the patient remains well for 5 years following treatment the diagnosis of "branchiogenic carcinoma" is less tenable and it is probable that an undetected primary lesion did exist somewhere in the pharynx, but was sterilized in the field of radiation to the cervical mass. (3) If the patient with any form of carcinomatous cervical tumor has died of the growth or was lost track of before 5 years without the discovery of a primary lesion then the diagnosis must remain indeterminate, since it is possible that a primary lesion did exist and remained silent or at least undiscovered up to the time of death.

In the case of a carcinomatous cervical tumor we consider as inconclusive any single negative examination for a primary lesion in the mouth and pharynx no matter how competent the examiner. The survival of the patient for at least 5 years is the only tenable proof that there is no primary growth elsewhere. One of the least tenable arguments advanced by those who favor the theory of the frequent occurrence of primary cervical cancer is that no primary was found on a single examination by a nose and throat specialist. If the examiner had been competent he would have realized that his single examination was inconclusive. Pathologists are particularly prone to fall into the error of drawing conclusions in such cases from the fact that they find no primary lesions in the mouth or pharynx at autopsy. Any clinician who has repeatedly searched for and finally located and proved by biopsy the smaller silent and more elusive primary lesions will have little confidence in the pathologist's ability to find such growths in the mouth or pharynx after death.

It is our considered opinion that many patients die of widely disseminated cancer

There are several bony structures in the neck of some importance in this connection because of the likelihood of confusion with and the need of differentiation from enlarged indurated lymph nodes. The greater cornu of the hyoid bone lies just anterior to the bifurcation of the carotid artery and may readily confuse the inexperienced. Pressure on the opposite greater cornu readily demonstrates that the supposed mass is actually part of the mobile hyoid bone. The transverse process of the sixth cervical vertebra (carotid tubercle) may be mistaken for a metastasis in the midportion of the internal jugular chain of lymph nodes.

When there is even a moderate degree of arteriosclerosis in thin persons, the carotid bulb may be unusually prominent. Since the main subdiaphragmatic node lies almost directly over this structure it is sometimes difficult to distinguish an enlarged lymph node transmitting arterial pulsations from the carotid bulb itself. In any of the above situations if a decision cannot be reached on the basis of clinical examination alone aspiration biopsy may solve the problem. If the report is positive the diagnosis is certain, but a negative diagnosis is of no value.

The probable benign or malignant nature of cervical tumors as judged solely by the clinical history. As we have already stated cervical tumors, whether malignant or benign seldom produce subjective symptoms until far advanced. For this reason the absence of discomfort or dysfunction is of little significance in differential diagnosis.

The stated duration if long of a cervical tumor can be of considerable importance. If for instance the patient states that the mass has been present for several years, the probability is that its character is benign or at least relatively so. It must be realized, however that thyroid cancer may develop in a

previously benign adenoma of several years duration and that the same is true of cancer developing in benign mixed tumors of the parotid and submaxillary salivary glands. Furthermore some soft part sarcomas are of relatively slow growth. On the other hand, metastatic carcinoma in lymph nodes grows rather rapidly that is, its duration up to the time of producing palpable tumors or even of producing disabling symptoms is usually a matter of months rather than years.

One of the most serious errors results from giving much credence to the patient's statement that a given mass 3 to 5 centimeters in diameter appeared suddenly as for instance, overnight. On the basis of such a clinical history some physicians are misled into believing that a given cervical tumor must therefore be benign that is, the result of inflammatory hyperplasia of a lymph node. It should be plain that such rapid lymph node enlargement from inflammation must of necessity have been preceded and accompanied by symptoms of acute sepsis in the mouth or pharynx. It is a common experience in cancer clinics that patients with histologically proved cervical metastases from demonstrable primary lesions will state that the cervical tumor 3 to 5 centimeters in diameter developed within a few hours. As a matter of general observational knowledge, it must take several weeks or even months for a metastatic tumor to reach such a size.

In brief when a patient states definitely that a given tumor has been present for several years, the clinical history may be of real significance from the standpoint of diagnosis. On the other hand a statement of the short duration (a few days) of a given tumor should be given no credence whatever in proceeding with measures for physical diagnosis, such as search for a primary growth, biopsy and similar steps.

Presumptive cancerous nature of enlarged cervical lymph nodes in the adult. One of us (H. M.) has published repeatedly the statement that chronic asymmetric enlargement of one or more cervical lymph nodes in the adult is cancerous in most instances and probably metastatic from a primary lesion in the oral cavity the oral or nasal pharynx. This

Close reading and personal communication with surgeons who speak of cervical lymph node metastases as "glands" forces one to the conclusion that many of them who use such terminology believe that cervical metastases from cancer take place indiscriminately in the various "cervical" glands, that not only do the lymph nodes but also the parotid salivary, submaxillary salivary, submandibular salivary and thyroid glands, and last of all the thymus gland, are of equal significance from the standpoint of cervical metastases. This error is extremely frequent, and of course to the surgeons who use the term "glands" the presence of palpable but otherwise normal submaxillary salivary, parotid salivary and thyroid glands, such they interpret as being derived by cancer. If the "glands" or lymph nodes were used instead of "gland" or "lymph gland," much of this confusion would be eliminated.

further add a part (or a questionable "whole") of a cervical mass is handed to the pathologist and a report of cancer returned. It cannot be too strongly emphasized that even though an excised cervical mass is proved histologically to be cancer nevertheless, the diagnosis is still incomplete until the possibility of a primary growth has been ruled out. About the same information as to the histologic character usually could have been obtained with much less effort, expense and loss of time by a biopsy from the surface of the primary growth or by an aspiration biopsy from the cervical tumor.

In certain cases, although the cervical mass is proved to be carcinomatous, and from its histologic appearance probably metastatic, nevertheless no primary growth can be found after repeated search. In these cases, the cervical tumor should be treated and the patient re-examined for a silent primary lesion at regular intervals, at least once a month for the first year and then every 2 to 3 months for a period of at least 5 years before the end result is considered conclusive.

If at the end of a 5 year period no primary lesion has been found in the mouth and pharynx, the patient is still free of disease and the histologic report is squamous or epidermoid carcinoma then a diagnosis of "branchiogenic carcinoma" may fairly be made. Until the 5 year period has elapsed, the tentative diagnosis should be "carcinoma, metastatic to the cervical lymph nodes—primary undiscovered."

Proof of the cancerous nature of enlarged cervical lymph nodes. On most of the clinical services at the Memorial Hospital it is a routine practice to make biopsies whenever possible before resorting to any major surgical procedure. Preliminary biopsy from ulcerated surface tumors is never omitted. Endoscopy and aspiration biopsy are employed in an effort to prove the histologic character of deep seated tumors. When the treatment is to be by radiation histologic confirmation is considered essential otherwise the cases in question can have little or no value for statistical purposes. In all cases of cancer it is a prudent policy not to subject a patient either to a major operation or to heavy irradiation with-

out histologic proof. If all available diagnostic facilities are utilized it will rarely be necessary to do so.

In general, these same principles hold true for cervical tumors or cervical metastases. If a primary lesion is found and proved histologically it is not necessary from the practical standpoint, similarly to prove the character of the cervical metastases before proceeding with surgical treatment, since the pathologic character of the excised nodes will be available for record. The latter however is not true of treatment by irradiation, in which case aspiration biopsy should be used to prove that the lymph node enlargement is actually of metastatic character. No matter how experienced the examiner his clinical opinion as to the character of cervical tumors is subject to considerable error.¹ In questionable cases, e.g. small nodes involved by early metastases, histologic proof should be obtained before indiscriminately embarking on a radical operation. Expediency is no justification for the performance of prophylactic neck dissections in the absence of clinical evidences of lymph node involvement.

Repeated examinations of the oral cavity and pharynx for silent primary malignant growths. A single examination of the mouth and pharynx does not rule out the possibility of a silent primary cancer in these regions, despite the experience and competence of the examiner. There are several areas, such as the base of the tongue, tonsil, or fossa of Rosenmüller which characteristically exhibit surface irregularity in the normal subject. For this reason a primary lesion if present may not be apparent on the first examination. In these sites, repeated inspection often reveals at some given point a slight difference in surface texture. In contour or in consistency to palpation. One should view with suspicion a tonsil slightly larger than its fellow or a small area of granular tissue protruding at the

¹On review of the neck dissections performed in the Head and Neck Clinic in the last several years, it is significant to note that most cases, as separate history of clinically positive nodes was made prior to proposing the major operation to the patient. Such procedure may at first thought seem superfluous, but supported by such evidence the confidence which the surgeon has in the accuracy for operation, transferred to the patient who will more readily accept advice and submit to the operation without delay. It rarely is the case that the patient refuses or delays an operation when advised by surgeon who feels that metastatic spread is present and that treatment should be immediate.

orifice of a tonsillar crypt, especially if on the same side as the enlarged cervical node. The irregularity of the surface of the base of the tongue is dependent upon the distribution and amount of lymphoid tissue in Waldeyer's ring. Small silent cancers may sometimes be found at the base of the tongue associated with lymphoid hypertrophy. Biopsy of suspicious areas at these sites will frequently reveal a silent primary growth.

Probable site of the silent primary cancer on the basis of chance alone. Given a cervical metastasis and adjudged solely on the basis of chance, the most likely locations of a silent primary lesion are, in the order of their frequency tonsil, nasopharynx, pharyngeal wall, extrinsic larynx, tongue, floor of the mouth and palate (Table III). The order of probability of a silent primary lesion being in any one of the several anatomic sites listed is directly proportional to their individual characteristics (1) function not affected by the presence of one or more of the following characteristics (2) a meager sensory nerve supply, (3) a relatively high proportion of primary cancer occurring at the given anatomic site, (4) the relative and absolute frequency of metastasis from growths at the given site, (5) the relative inaccessibility of the given anatomic site to physical examination.

Position of the lymph node metastasis as an indication of the location of the silent primary growth. It is probably not generally realized that the anatomy of the cervical lymphatics has been recorded in minute detail by anatomists, and that in many respects these lymphatics have constant and uniform features. In brief, certain main lymph channels are always present at the same location, e.g., the internal jugular chain, the spinal accessory chain, the submaxillary and submental node groups, etc. These lymph channels with named lymph nodes and lymph node groups always receive the main lymph drainage from relatively specific anatomic areas although there is some overlapping and no distinct line of demarcation. Nevertheless, this relationship between node groups and a tributary anatomic area is constant enough to permit certain deductions, and it is possible for an ex-

aminer logically to suspect a primary lesion located in a given tributary area when a lymph node metastasis appears at a respective place in the neck. In Figure 2 are shown various lymph node groups with the most likely sites of the primary lesions which may cause the metastases.

The occurrence of lymph node metastases under the upper end of the sternomastoid muscle is of particular value as suggesting a primary lesion in the nasopharynx, even though physical examination fails to reveal any abnormality in the latter region, since the spinal accessory chain receives lymph drainage practically only from the nasopharynx. The same is true of the preauricular parotid node which receives drainage principally from the temple, scalp, eyelids, and orbit. It should be realized, however, that exceptions occur with sufficient frequency so that no portion of the mouth or pharynx should be omitted from careful examination.

Aspiration and incisional biopsy. If a silent primary lesion is not discovered on first examination, it is probably best to make an aspiration biopsy of the suspected cervical metastasis before the patient leaves. The technique of this procedure has already been published (13) and will not be described here. The reason for making an aspiration biopsy rather than waiting for a further examination of the mouth and pharynx is that by this means, it is possible to prove the malignant character of the cervical tumor and with this knowledge, both the surgeon and the relatives or even the patient himself may realize fully the necessity for prompt additional diagnostic or therapeutic measures. While aspiration biopsy seldom permits grading of the tumor, in competent hands it will almost always permit a diagnosis between a malignant and a benign process. An additional advantage is that the puncture of the lymph node metastasis or cancerous mass does not change the clinical setting. It does not require hospitalization or more than a minor operative procedure. Incisional biopsy should be reserved for those cases in which aspiration biopsy has failed to disclose any positive information.¹

¹Even though there are clear histories of previous treatment (either radiological or surgical) of a primary lesion in the mouth or pharynx surgeons occasionally refer patients to a cancer clinic after they have

diagnosis of lymphosarcoma of cervical lymph nodes should not discourage the search for, and the treatment of, a primary lesion in the mouth or pharynx.

2 *Hodgkin's disease* A diagnosis of Hodgkin's disease should not be made until an orderly sequence of diagnostic procedures has been carried out. It should be remembered that the chances in an adult of an enlarged cervical node being involved by metastatic cancer are far greater (about 9 to 1) than of being a primary lymphoma (lymphosarcoma, Hodgkin's disease or leucemia). Hence, the first procedure should be a thorough search for a primary growth in the mouth or pharynx on the assumption that, based on chance alone, such a primary lesion exists. If this search reveals nothing definite, an aspiration biopsy should next be made. If this fails to show metastatic cancer, then only should one resort to incisional biopsy. For differentiation between specific lymphoma groups, aspiration biopsy often is not satisfactory. In general, Hodgkin's lymph nodes are firm and scattered in the neck. According to Slaughter and Craver in an analysis of 265 cases, the apparent origin of the disease is most often (65 per cent) in the neck.

3 *Leucemia* Among the malignant lymphomas, there should also be included those cases of leucemia in which the original picture is that of cervical tumors often resembling lymphosarcoma histologically. In the early leucemic phases, only a slightly abnormal blood picture may be found and differentiation is difficult. However, a white blood count should always be made in conjunction with the biopsy of the lymph node, before a conclusive diagnosis of lymphosarcoma is made.

4 *Primary carcinoma of cervical lymph nodes* Several theories have been advanced to explain the occurrence of cervical carcinomatous masses without demonstrable primary lesions in the mouth or pharynx. One of these theories is that such growths arise in lymph nodes from epithelial rests. Lwing, in a personal communication, stated to us that he has observed in cervical lymph nodes remnants of glandular acini which he interpreted as embryonal rests, but he con-

ceded that he has never seen any remnant squamous epithelium in lymph nodes which could possibly be of branchial cleft origin. Stewart, also in a personal communication to us, stated that he has never observed any cellular elements in normal cervical lymph nodes which he could interpret as being of epithelial origin. He suggests that since lymph nodes are normally present within the parotid and submaxillary salivary glands, histologic preparations might show glandular tissue adhering to, or, as artefacts, apparently within, such lymph nodes.

Another possible explanation for the few and isolated reports of epithelial rests in lymph nodes is the marked lymphoid hyperplasia that sometimes occurs in the walls of branchial cysts, occasionally producing almost solid tumors. The latter might be interpreted as being partly caseous lymph nodes and fragments of the cyst wall as epithelial rests. In any case, it seems to us that the evidence is rather tenuous for the existence of epithelial rests within lymph nodes giving rise to cancer. We do not believe that such a hypothesis is necessary to explain the etiology of cervical tumors.

5 *Endothelioma of lymph nodes* The term "endothelioma" is applied by pathologists to those tumors which develop from the cells lining blood vessels, lymphatics, or serous cavities. In the present discussion, we are concerned only with the question of endothelioma arising primarily in lymph nodes. According to Ewing, the lymph nodes were included among the probable sites of origin of endothelioma by Zahn in 1874 under the term *sarcoma alveolare epitheloides*. In 1914, Ewing divided primary malignant tumors arising from lymph nodes into two groups, first, the reticular form or reticular cell sarcoma, and second, the endothelial form or endothelioma, which he believed to arise from cells lining the lymph vessels and sinuses.

Following Ewing's publication in 1914, and up to the present writing, endothelioma of lymph nodes has been described by many pathologists as producing solid tumors of infiltrating character, eventually involving more than one lymph node and sometimes becoming systemic. They caution, however, that

In the preparation of this report a total of about 150 cases of malignant tumors of the thyroid were reviewed. In 14 cases (about 9 per cent) the clinical diagnosis on admission was that of cervical metastatic cancer, and a diagnosis of primary tumor in the thyroid was made only at operation. In some of these cases a fairly large primary thyroid tumor was found at operation in close proximity to an even larger lymph node metastasis, in others, a small primary tumor of the thyroid was found either at the time of operation or on later histologic examination. It is somewhat difficult to evaluate exactly these clinical data since often it is impossible at operation to differentiate anatomically between a lymph node metastasis in the internal jugular chain and a primary tumor in a posterior extremity of the thyroid gland, and the exact diagnosis may depend upon the impression of the individual surgeon.

Branchiogenic carcinoma. The belief that cancer can arise in embryonic or vestigial remnants of the branchial clefts dates from von Vollmann (1882). In the human embryo the structures of the face, neck, pharynx and larynx develop from the branchial apparatus. The first cleft forms the external auditory meatus and the remaining clefts or pharyngeal pouches give rise to the tympanic cavity, the pharyngotympanic tubes, the tonsillar pits, the thymus and parathyroids. It is believed that an irregularity in the closing of these branchial clefts results in reduplication of organs or in fistulous tracts, epidermoid or dermoid cysts, blood and lymph cysts. Although malignant tumors theoretically may arise in any of these vestigial structures, nevertheless, a diagnosis of branchiogenic carcinoma can be made only by exclusion, in our opinion.

Ewing, in discussing this subject, states that after the possibility of metastatic carcinoma, primary endothelioma and carotid body tumors have been ruled out, "there remains a group of apparently primary carcinomas of the cervical lymph nodes whose origin is obscure, and some of these may be derived from the endodermal epithelium of branchial cysts." Others have doubted the existence of branchiogenic cancer. As early as

1802, Sutton, in his discussion of mouth and pharynx cancer wrote as follows:

"One of the facts connected with epithelioma of the mucous membranes of the mouth is the extraordinary size which the infected lymph glands in the neck sometimes attain whilst the primary ulcer scarcely exceeds 1 cm in diameter. This is worth bearing in mind because an enlargement of a cervical lymph gland in individuals past middle age should always induce the surgeon to examine the various recesses of the mouth and fauces for small, inconspicuous epitheliomatous ulcers and with every care they sometimes escape detection during life. It is necessary to emphasize this because a good deal has been written about 'branchiogenic cancer' or as it is sometimes called, 'malignant cyst' of the neck. Some writers are of the opinion that these are primary epitheliomata arising in remnants of branchial clefts. My belief is that, in most of the cases, these gland masses are secondary to epithelioma originating in recesses of the pharynx or nasopharynx and the theory that they arise in remnants of branchial clefts is pure fiction."

In the head and neck clinic at Memorial Hospital, the diagnosis of branchiogenic carcinoma in any individual case is viewed with skepticism and is never made even tentatively except under the following conditions: (1) The patient must have survived at least 5 years free of disease, (2) treatment must have been directed only to the cervical tumor situated along the line of embryonic branchial clefts (i.e., between the external auditory meatus and the midline), in the line of the great vessels, (3) histologically, the tumor must have been squamous or epidermoid carcinoma.

We have observed too many cases in which a primary lesion in the mouth or pharynx appeared only after 2 or 3 years to consider seriously as branchiogenic carcinoma any malignant tumor mass in the neck, simply because no other adequate explanation is immediately available. A common example of an erroneous picture found in single case reports in the literature on branchiogenic carcinoma reveals a succession of events about as follows. A surgeon is consulted by a patient because of a cervical mass. The patient is then referred to a nose and throat specialist (probably not greatly interested in cancer). A report is returned stating that there is no growth in the mouth or pharynx and is accepted as conclusive. From then on, the physician does not believe it necessary to

make any further examination of the mouth or pharynx. The cervical mass is removed, diagnosed histologically as epidermoid carcinoma and *ergo* the case is recorded as branchiogenic carcinoma.

During the period covered by this report (1933-1937) there were 55 cases on our service in which the only complaint was of a cervical mass, in which the histologic diagnosis was epidermoid or squamous carcinoma and in which no primary was ever found. Only 8 of these have we finally diagnosed as branchiogenic carcinoma (based on fulfillment of the criteria mentioned). Even these are not indisputable since it is at least theoretically possible that in some, the undiscovered primary lesion may have been caught and sterilized in the field of radiation to the cervical mass. In the remaining 47 cases, the patients are either dead of cancer or lost track of. Since none of these latter cases were followed for a satisfactory period of time (at least 5 years) they have all been diagnosed as "carcinoma, metastatic to neck—no primary found."

A review of the literature on branchiogenic carcinoma is rather confusing and unsatisfactory. In most cases, the conclusion that

no primary lesion exists is based upon such examinations of the mouth and pharynx. We have not found any reported case of branchiogenic carcinoma with a 5 year follow-up with the patient free of disease following treatment for cervical masses.

Carotid body tumor. In a discussion of the differential diagnosis of cervical tumors, the subject of carotid body tumors must of course be included. On the other hand, this tumor is so rare that it need scarcely be considered from the practical standpoint in patients complaining of cervical tumors. A special study of this growth by one of our staff (Dr. William S. MacComb) revealed only 159 definitely proved cases reported in the literature in addition to the 6 cases observed (but not reported) at the Memorial Hospital. Carotid body tumors are always situated at the position of the carotid bifurcation—an observation of little diagnostic significance since this area is also the site of the lymph node group (the subdiaphragic) most frequently involved by metastatic cervical cancer. An oft mentioned and we believe overemphasized diagnostic sign of carotid body tumors is their alleged immobility in the vertical plane. Enlarged lymph nodes lying on the internal jugular vein are also relatively immobile in the vertical plane.

The only significant clinical characteristic of carotid body tumors from the diagnostic standpoint in our opinion is a pronounced and relatively superficial arterial pulsation. After the tumor has reached a diameter of 4 to 5 centimeters, it tends to grow deeply medial to the common carotid artery, and the pulsation of this artery and its branches can then be made out on the superficial surface of the tumor. In the smaller tumors (3 to 3.5 centimeters in diameter) the superficial position of the artery may not be evident except after surgical exposure when the location of the tumor directly in and also deep to, the crotch of the artery is immediately apparent.

Dr. Fred Stewart of Memorial Hospital has made a histologic diagnosis of carotid body tumor on aspiration biopsy in 2 cases in the past year. The correct preoperative diagnosis of this tumor is important before treatment since the necessary surgical exci-

Typical but by no means unique examples of unreported case reports of branchiogenic carcinoma are the following:

Letter Case and I noted report the case of "max. cyst 22, with an 'undiscovered' site of the lower lip and 'head, deeper placed' in the left submandibular region." Both lesions were excised and examined histologically. The site of the lip was diagnosed as "epithelioma, grade 3" and the submandibular tumor as "malignant cyst, grade III." A few months later, second "malignant cyst" was removed from the right submandibular region. Two and one-half years later, third cyst was removed from the submandibular region. The latter was also found to be "malignant cyst." The authors diagnosed the fact that the clinical history was typical of cancer of the lip with cervical metastases, distinct from metastases in the difficulty in proving of the tumors of the lip and neck, respectively, as reported by the pathologist. The authors conclude that the cervical history was "typical branchiogenic carcinoma arising in the mixed branchial and the 'epithelioma' (sh) cysts, respectively, in patients with cancer of the lip."

A second example of an unreported case report of branchiogenic carcinoma with an even more disconcerting sequel is that of a woman. He reports the case of "malignant cyst" was excised, histological study of "Tuberculosis of the larynx" had previously been made for the reason that "the larynx had peculiar pulse of the post-a procedure many years and throat most common tuberculosis." The author states that "under the right axilla, deep in the neck was another firm, fixed mass the size of an olive, directly beneath the angle of the jaw. A pathologist reported it as 'malignant cyst' with the patient previously having an artery and 'with considerable difficulty' he managed to locate some of the artery past the esophagus, which showed anastomosis against the area of the tumor in the neck. After preliminary parathyroid (the cervical mass (the size of an olive) was purposely exposed and a specimen was removed for biopsy. The histologic examination proved 'cancer of the thyroid gland, metastatic to the neck, highly malignant in character.'"

Although the history and clinical setting were typical of cancer of the larynx and the upper end of the esophagus with cervical metastases, yet despite the fact that "cervical tumor 'the size of an olive' could hardly be still have caused dysphagia of 'malignant' duration, nevertheless, the author concludes that this was carcinoma arising from an epithelial rest or an ectodermal branchial cleft."

sion or ligation of the internal carotid carries such a high operative death rate, and the average clinical course is so benign in the untreated case that we believe this tumor should usually be considered a *noli me tangere*

Primary tumors of soft parts of the neck (excluding lymph nodes) The soft parts of the neck may give rise to practically any of the various tumors of the nerve, muscle, fascial and vascular tissues, and when such growths are situated along the line of the internal jugular vein, they may present difficulties in the differential diagnosis of metastatic cervical cancer. The superficial character of some of these growths or their origin within an anatomic structure such as the sternomastoid muscle may give a clue to their character. In all such cases, the diagnosis will ultimately depend upon the histologic report. Aspiration biopsy may conclusively settle the question in some of the cases, and in others, it may be necessary to make an incisional biopsy. From the practical standpoint, it is important to realize that the incidence of primary soft part tumors of the neck is rare as compared to metastatic cervical cancer.

Acute infection A common error in clinical diagnosis is to mistake cervical metastatic masses for inflammatory hyperplasia of lymph nodes. On this basis, sepsis in the tonsils or about the teeth is often held responsible and therefore the tonsils are often removed or teeth extracted. The nose and throat clinics where the excised tonsils are subjected to routine histologic examination discover many cases of primary cancer of the tonsils in this manner. When the primary growths are large, there is invariably residual cancer in the tonsillar fossa following tonsillectomy. The frequency with which an error in diagnosis of chronic tonsillitis is made in cancer of the tonsil is illustrated by the following observation made at Memorial Hospital. In a series of 157 consecutive cases of patients with cancer of the tonsil admitted to Memorial Hospital, 15 (10 per cent) had had simple tonsillectomies performed prior to admission as a result of a clinical diagnosis of chronic tonsillitis with cervical lymph node enlargement.

Similarly, in cancer of the base of the tongue, about 30 per cent of the patients applying to

Memorial Hospital complain only of a cervical tumor, that is, a cervical metastasis. Over a 4 year period, we have observed 8 instances of cancer of the base of the tongue in which tonsillectomies had been performed within a month prior to the patients' first appearance at Memorial Hospital. In these cases, it can be fairly assumed that the operating surgeon attributed the cervical lymph node enlargement to sepsis from the tonsils. It is also probable that in these cases, the unrecognized primary lesion in the base of the tongue must have been pushed aside to facilitate exposure of the operative field for the tonsillectomy.

When carious teeth are considered responsible for enlargement of cervical lymph nodes, the patient is usually referred to a dentist for extraction. The dentist naturally accepts the diagnosis of the physician and the patient ordinarily remains under his care for several weeks or months before any other attempt is made at further diagnosis.

While enlargement due to hyperplasia of regional lymph nodes can occur as a result of local sepsis, it is seldom that there is slow, gradual enlargement without suppuration. In our experience at the clinic in Memorial Hospital, we rarely find it necessary to make a diagnosis of inflammatory hyperplasia of lymph nodes. In this connection, it is necessary to distinguish a slight (2 to 2.5 cm in diameter) soft, tender enlargement of the cervical lymph node which occurs in acute tonsillitis, and the slow, progressive, firm enlargement to several centimeters in diameter which occurs as a result of metastasis. It is of course not possible to estimate the relative frequencies of inflammatory hyperplasia and metastatic cancer as a cause of cervical tumors, but it is significant that such unprejudiced observers as Cecil, in his discussion of inflammatory cervical lymph node enlargement, confines his observations to the diseases of childhood (scarlet fever, measles, etc.) In the adult, an asymmetrical enlargement of a nontender lymph node resulting from sepsis is undoubtedly rare and should not be considered until cancer is ruled out.

Tuberculosis Next to cancer, the most common cause of chronic asymmetric enlarge-

ment of cervical lymph nodes is tuberculosis. Such patients are frequently referred to the Memorial Hospital with a tentative diagnosis of cancer. On the other hand the erroneous diagnosis of tuberculosis in cases of metastatic cancer is rarely made by the first examining physician. When tuberculous cervical lymph nodes have been present since childhood with a history of suppuration and discharging sinuses there is, of course, no reason for confusion in diagnosis. Rapidly enlarging bulky unilateral, asymmetric enlargement of cervical lymph nodes even in childhood is more likely to be cancer than tuberculosis. One of us (H. M.) has discussed this subject as related to childhood cancer in a previous publication (11). On the other hand tuberculous enlargement of cervical nodes sometimes appears in the adult with a history and physical findings identical with that of cancer and in these patients, the correct diagnosis can be made only by biopsy.

Syphilis¹ From the standpoint of diagnosis in mouth and pharyngeal cancer the question of syphilis is the source of more confusion and error than is any other disease and one cannot escape the conclusion that in present day medical education at least some aspects of the syphilis problem have been overempha-

sized. From the histories of mouth cancer patients before coming to a cancer clinic, there appears to be a widespread, erroneous belief that syphilis is a frequent cause of asymmetric, bulky enlargement of cervical lymph nodes. Such a phenomenon is not discussed by syphilologists and has never been observed at Memorial Hospital. In the present report, we are concerned only with the diagnosis of cervical metastasis and, in this connection, we are of the opinion that there is no logical reason why any well informed physician should ever consider the possibility of syphilis in the presence of an asymmetric, bulky enlargement of a lymph node in any part of the body. In the Head and Neck Clinic at Memorial Hospital where about 1500 new cases of cancer of the head and neck are seen yearly no instance of cervical lymph node enlargement due to syphilis alone has ever been proved.

Branchiogenic and thyroglossal cysts The most common site of origin of branchiogenic cysts is at about the level of the greater cornu of the hyoid bone. Confusion in diagnosis is likely to occur because of the proximity of the subdiaphragmatic lymph nodes and the fact that these nodes are more frequently involved by metastatic cancer than is any other cervical lymph node group. Sometimes these cysts are thin-walled and smooth of contour slightly fluctuant on palpation, and in such cases, the cystic character may be fairly obvious on physical examination. In other cases, the wall is thickened sometimes almost a centimeter and in these, the consistency is rather firm on palpation and cannot be distinguished from solid masses. In the latter the clinical picture is almost exactly that of cervical metastatic cancer but in any case if the correct procedure of clinical investigation is followed, these cases will present no difficulties in diagnosis.

If no primary lesion is found on examination of the mouth or nasopharynx, the tumors should be aspirated at the first visit. The thin walled cysts are usually filled with a straw-colored fluid and will completely collapse on aspiration. The diagnosis, therefore will be clearly established. Arrangements can then be made for the surgical excision after a

¹Two forms of lymph node enlargement, always of moderate degree—ilateral and symmetric, are discussed by syphilologists (2, 3, 17, 19). The first form is that which occurs in the regional lymph nodes at the time of the primary chancre. The second, the generalized lymph node enlargement, is not so common. It is also seen in the secondary stage, when considerable diagnostic significance is attributed to the palpability of certain lymph node groups, such as, epitrochlear, axillary, and posterior cervical. According to Kyrle, the asymmetric lymph node enlargement of syphilis usually disappears about a year following the primary chancre and from then on rare.

Most syphilologists do not clearly define, but they mean by lymph node enlargement, however, and appear to us that they consider even slight palpability to be abnormal. Frobenius points out that unilateral or isolated lymph node enlargement has no significance in the diagnosis of syphilis, although he believes that a moderate enlargement is of great significance in the diagnosis of this disease. The choroid, nevertheless, that between 1 per cent and 3 per cent of general individuals have palpable lymph nodes even in such supposedly insignificant areas as the epitrochlear and axillary nodes.

Bosch has reported gonorrhea to occur in lymph nodes and to produce unilateral cervical tumors in colored people only. He states the question here is of what has most of the time been reported as lymph node enlargement by Bosche were not actually metastatic cervical cancer as supposed by him when he had syphilis.

A positive Wassermann test often leads to a diagnosis of the syphilitic nature of the primary lesion or of the metastases in mouth and pharyngeal cancer. Such erroneous diagnosis are most likely to occur in cancer of the tongue, where in almost 99 per cent of all cases, the growing syphilitic granules with positive Wassermann test have been one of the main factors in the primary of the malignant growth. An incorrect diagnosis of syphilis alone, based on the positive Wassermann test, is also likely to occur in the colored race. Mixed with mouth or pharyngeal cancer since the incidence of syphilis is high among these people. In the presence of lesions resembling cancer, the Wassermann test should be completely discarded until a syphilitic diagnosis can be made.

In brief, the moderate bilateral enlargement of all superficial lymph nodes, which is characteristic of syphilis, bears no resemblance to the asymmetric, bulky unilateral enlargement of a single node or group of nodes in metastatic cancer.

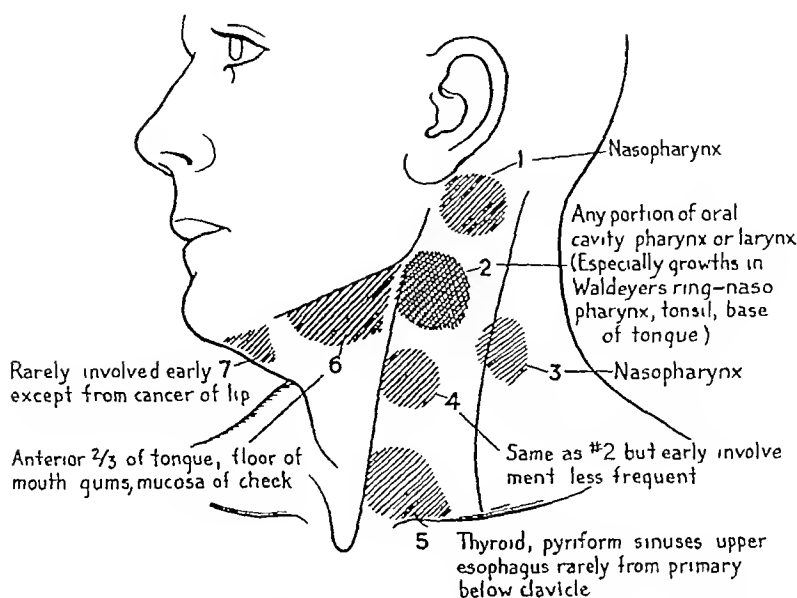


Fig 2 Various lymph node groups with the most likely sites of the primary lesions which may cause the metastases

week or two when the cyst has refilled so as to be more easily handled surgically. The thick walls are due to a lymphoid hyperplasia, and the aspirated contents will consist of serous or mucoid fluid with desquamated epithelial debris. In these cases, the collapse of the cyst will be only partial, but the diagnosis and method of treatment by surgical excision is about the same.

Thyroglossal cysts occur always in the midline of the neck, either above or just below the level of the hyoid bone. When situated above the hyoid, they could conceivably be confused with metastatic submental lymph nodes. Thyroglossal cysts are frequently referred to cancer clinics for diagnosis.

DISCUSSION

The clinical data used in this report have been assembled from the case records of a variety of the many anatomic forms of cancer. These data have been analyzed and correlated to provide the broad perspective which we consider essential to the full understanding of a frequently encountered and rather complex clinical problem, namely, that of cervical metastatic cancer of obscure origin. In such cases, even though the histologic character of

the growth has been established, treatment can rarely be permanently effective unless the location of the primary tumor is also discovered and proved histologically. One must concede that both the accepted methods of treatment (surgery and radiation) are strictly local in action and that to be safe and useful, they must be restricted to the volume of the primary growth and all metastases. For this reason, it is axiomatic that cancer can scarcely ever be cured without a complete anatomic diagnosis as to the site of the primary growth. The only and largely theoretical exceptions to the rule would be those cases in which an undiscovered primary growth might fortuitously be included in the field of effective surgery or irradiation, purposefully directed only toward demonstrable metastases. In the final analysis, however, there can be little question but that almost all patients whose primary lesions remain silent and undiscovered are doomed to die of cancer. Only if and when a systemic remedy for cancer is discovered will it be possible to cure this disease without regard to the primary site of the growth.

At this point in the discussion, it seems pertinent to summarize the most common errors

in clinical management which lead to delay in or failure of a complete diagnosis in cases of cervical metastasis from silent primary growths. These errors may be briefly summarized as follows:

COMMON ERRORS IN DIAGNOSTIC PROCEDURE IN CASES OF CERVICAL TUMORS

Failure to recognize the probable cancerous nature of most cervical tumors in the adult and as a result, the treatment or observation only of such tumors as benign (inflammatory, tuberculous, syphilitic, etc.) without recourse to histologic diagnosis.

2. Failure to recognize the probable metastatic character of histologically proved malignant cervical tumors.

3. Failure to examine the mouth and pharynx for silent primary lesions of cancer in all cases of undiagnosed cervical tumors.

4. Failure to appreciate that one or even several examinations of the mouth and pharynx, even by highly competent and experienced examiners, does not permanently preclude the possibility of small primary lesions of cancer which will eventually become obvious.

5. Failure to realize that incisional biopsy should be used only as the last resort and never as the initial diagnostic procedure in cases of cervical tumors.

It also seems useful to us to outline the proper order of procedure for diagnosis in such cases. This procedure may be summarized as follows:

METHOD AND ORDER OF PROCEDURE FOR DIAGNOSIS OF PATIENTS COMPLAINING ONLY OF CERVICAL TUMORS

First visit

1. Obtain a clinical history with particular attention to disregarded symptoms such as:
 - a. Deafness, ringing or stuffiness in one ear
 - b. Slight soreness in the mouth or throat or difficulty in swallowing.
 - c. Obstruction of one nasal cavity
 - d. History of an operation (or treatment) in the mouth or pharynx some previous time, even several years before
2. Note the position of the cervical tumor and consider the probability of its being an enlarged lymph node. From the position of the node determines the most likely site of the silent primary lesion (see Fig. 1)
3. Carefully examine the mouth and pharynx with headlight and throat mirror
4. If no primary lesion can be demonstrated readily consider the indications for biopsy from such areas as:

- a. A partly obliterated fossa of Rosenmüller in the nasopharynx.
 - b. Asymmetrical enlargement of one tonsil or an indurated area within a tonsil.
 - c. Asymmetrical beeping up of lymphoid tissue at the base of the tongue.
5. Examine the thyroid for the presence of small primary tumor
 6. Make an aspiration biopsy of the cervical tumor
 7. Consider indications for radiographic or endoscopic examination of the pyriform sinuses and the upper end of the esophagus.

Second visit

8. If the aspiration biopsy report is anaplastic carcinoma, re-examine particularly the nasopharynx, the tonsil, and the base of the tongue. If the report of the aspiration biopsy is negative in character repeat the aspiration once or more.
9. Correlate all physical, radiographic, endoscopic and histological data.
After all other diagnostic resources have been exhausted, consider complete excision of the cervical tumor or of one of several nodes for histologic examination.
If no primary lesion can be disclosed, treat the cervical tumor or tumors and continue the search for a primary lesion by thorough examination of the mouth and pharynx at monthly intervals for the first year or two and at slightly longer intervals for at least 5 years before considering the diagnosis complete.

So long as a portion of the medical profession remains satisfied with such diagnoses as "carcinoma of the neck" without thought of the probable metastatic character of the growth and the location of the primary lesion, and so long as death certificates giving only the site of the metastatic cancer are signed by physicians and accepted for registration and record by health authorities, it is obvious that little progress will be made in the interests of those patients who complain only of cervical tumors and whose primary growths are silent.

Common errors in diagnosis and treatment of initially symptomatic cervical metastatic cancer
In our list we mention several common errors in procedure which are found to be responsible for delay or absence of complete diagnosis in cases of cervical metastatic cancer with silent primary growths. Since these misconceptions and errors in procedure have been repeatedly stressed in the foregoing text it seems to us that beyond their listing for reference, no further elaboration is required here.

Plan of procedure for diagnosis in cases of patients complaining only of cervical tumors

From the foregoing analysis of clinical data, one should be able to formulate a logical system and order of procedure for the differential diagnosis of cancer in cases of cervical tumors. Such a plan has been outlined. It seems to us, however, that the greatest obstacle to the general acceptance and use of such a scheme is the difficulty in demonstrating its necessity. The clinical data which we have presented in this report force one to the conclusion that too many physicians are unfamiliar with the early clinical course of cancer and unmindful of the necessity of early and complete anatomic diagnosis, if the patient is to have a reasonable chance of cure. When an error or delay in diagnosis of cancer occurs, the responsible physician himself seldom has to face the tragic consequences to the end. That illuminating experience is reserved for the staffs of the cancer clinic or the home for incurables and last but not least for the patient himself and his family. For this reason we have laid so much emphasis on the frequency of the characteristic clinical course of initially symptomatic cervical metastasis.

Although the detailed procedures in our outline may at first appear to be too numerous and complicated, a more careful consideration and trial will prove that they are not difficult to carry out. With such an approach, the silent primary growth is often disclosed within 2 or 3 minutes. Even if the primary growth is more obscure, the details of the examination on the first visit, including an aspiration biopsy, can be carried out within 15 minutes. Radiographic and endoscopic examination will usually require a second visit. A complete understanding of this problem requires the conviction that a primary lesion *probably exists somewhere*, even though it cannot be disclosed at first. Viewed in this manner, the diagnosis of cervical cancer is considered tentative only until a primary lesion is discovered or until the patient has survived for 5 years following treatment to the cervical tumor alone.

SUMMARY

Cervical metastasis as the first and for a time the only symptom of cancer is discussed

from the standpoints of definition, incidence, anatomic location of the silent primary growths, subsequent clinical course and differential diagnosis. The importance of early discovery of the silent primary tumor is emphasized. Common errors in management of and a logical plan of procedure for the differential diagnosis of cancer in cervical tumors are discussed.

CASE REPORTS

CASE 1 Delay in diagnosis in a case of cancer of the nasopharynx erroneously diagnosed as "Hodgkin's disease."

Charles N., male, aged 55 years, was first seen in the admitting office of Memorial Hospital in October, 1942. About 4 months previously he had first noted a "lump" in his left upper neck (Fig. 3) not associated with any subjective symptoms. A few weeks later he went to a hospital where an incisional biopsy was made and a histologic diagnosis of "Hodgkin's disease" returned. He was then referred to the Memorial Hospital.

In the admitting office of Memorial Hospital the question of cancer of the thyroid was raised, but no examination of the nasopharynx was made. A letter was written asking for a loan of the slide but when it was received after a week's delay the pathologist pronounced it "unsatisfactory for diagnosis." A second incisional biopsy of a cervical node was made in the admitting office and a report of "metastatic carcinoma" was returned. On the basis of this report re-examination was made of the upper respiratory and alimentary tracts, and the nasopharynx was found to be filled with a bulky tumor which was causing no symptoms. The patient was then referred to the head and neck service where a biopsy specimen was removed from the nasopharynx. The diagnosis was "anaplastic epidermoid carcinoma."

The delay in diagnosis occurred in this case because the admitting officer of the Memorial Hospital was influenced by the previous erroneous diagnosis of "Hodgkin's disease" and failed to realize that the clinical findings were more typical of metastatic cancer than of Hodgkin's disease. If a thorough examination had been made at the time of his first visit to Memorial Hospital the primary lesion in the nasopharynx would undoubtedly have been discovered, a biopsy specimen removed, and the correct diagnosis established immediately without the necessity of the eventual removal of an enlarged cervical node. In this case the proper treatment for cancer of the nasopharynx was unnecessarily delayed.

for about 10 days following application to the Memorial Hospital.

CASE 2. Delay in diagnosis in a case of epidermoid carcinoma of the pharyngeal wall in a patient complaining only of cervical tumor.

Lorraine L., female, aged 40 years, was first seen in the admitting office of Memorial Hospital in July, 1932. She stated that 6 months previously she had first noted swellings in both sides of the neck (Fig. 4) which had slowly progressed. No other symptoms were elicited. Her family doctor had examined her on several occasions and had finally referred her to the Memorial Hospital.

In the admitting office of the Memorial Hospital clinical diagnosis of Hodgkin's disease was made and an aspiration biopsy was performed with a report of "lymphoid tissue only." An incisional biopsy was then carried out and diagnosis of "transitional cell carcinoma" was returned. With this report, the patient was referred to the head and neck clinic where on the first examination nonulcerated, bulging tumor was found on the lateral pharyngeal wall extending up into the nasopharynx. A biopsy from this mass was reported as showing "transitional cell carcinoma."

Because of a similarity in the clinical appearance to some cases of Hodgkin's disease, no adequate examination of the upper respiratory and alimentary tracts was made in the admitting office. The correct diagnosis was made only after an unsuccessful aspiration biopsy and an incisional biopsy, although the pharyngeal tumor was obvious on inspection of the pharynx. Had the admitting officer realized that the symptoms were more characteristic of cervical metastatic cancer than of Hodgkin's disease a more careful examination would have been made at the time of the first visit and the primary lesion in the pharynx immediately disclosed. The avoidable delay in diagnosis in this case was only about 2 weeks but properly managed the diagnosis could have been made without resorting to removal of a cervical node.

CASE 3. Unavoidable delay of 8 months in the complete diagnosis in a case of denocarcinoma of the base of the tongue in a patient complaining only of cervical tumor.

George P., male, aged 64 years, was first seen in the admitting office of Memorial Hospital in April, 1934. Six months prior to admission he had noted a swelling in the upper left neck (Fig. 5). After a delay of about 5 months he applied for examination to another hospital, where a clinical diagnosis of cancer was made and he was immediately referred to

Memorial Hospital without any further examination.

On application to the Memorial Hospital he was referred directly from the admitting office to the head and neck clinic where no primary lesion was found after examination of the upper respiratory and alimentary tracts. An aspiration biopsy of the cervical tumor was then made and report returned of carcinoma—suspected salivary gland origin. The cervical mass was treated by a combination of x-ray and radium and a systematic search was continued for a primary lesion. The oral cavity and pharynx were repeatedly examined at intervals of about 2 weeks. The patient was bronchoscoped and esophagoscoped and x-ray examinations of the chest and gastrointestinal tract were made.

A year after the first visit, on the 35th routine examination of the upper respiratory and alimentary tracts for a primary lesion, a small, superficial ulcer about 3 to 4 millimeters in diameter was noted at the left base of the tongue. A biopsy specimen was removed from this area and found to be identical histologically with the cervical tumor.

In this case the cervical tumor was believed from the first to be metastatic and a systematic search consisting of a series of about 25 examinations over a period of a year was made for the primary lesion. The primary growth, when discovered, was so small that it probably was not previously discernible to the naked eye.

CASE 4. Delay in diagnosis in a case of squamous carcinoma of the base of the tongue in a patient complaining only of cervical mass whose diagnosis was missed because no examination of the mouth was made.

John T. male, aged 63 years, first applied to the Memorial Hospital in May, 1933. Four months prior to admission, friend had called his attention to a swelling in the right side of his neck (Fig. 6). Three weeks later he consulted his family physician and was referred to a surgeon, who made an incisional biopsy of the cervical mass. A histologic report of "squamous carcinoma" was returned. The surgeon then referred him back to his family doctor without any examination of the oral cavity and on the basis of the histologic report the patient was referred to the Memorial Hospital. In the admitting office a bulky primary lesion was immediately discovered in the right base of the tongue.

In this case the patient with a cervical tumor passed through the hands of his family doctor and a surgeon without any examination of the oral cavity for a primary lesion of cancer although the surgeon performed an incisional biopsy of the cervical mass which disclosed cancer. The primary tumor in the

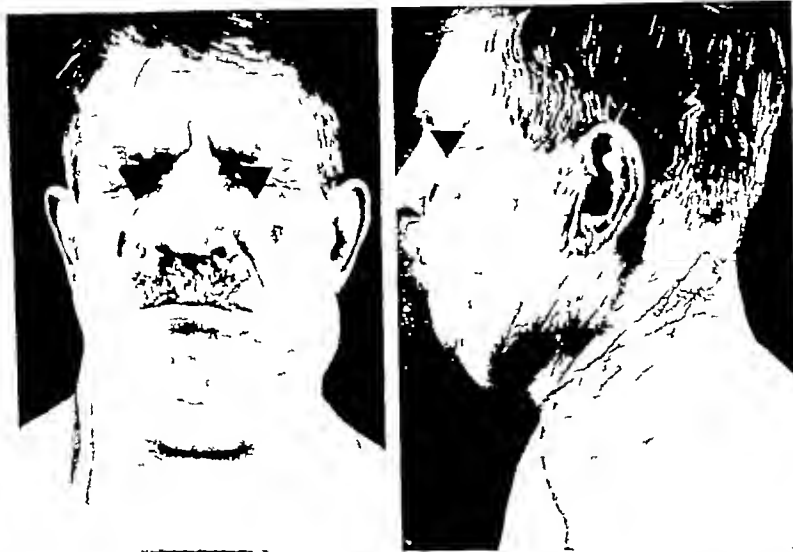


Fig 3 Case 1, Charles N Delay in diagnosis in a case of cancer of the nasopharynx at first erroneously diagnosed as Hodgkin's disease The only complaint was of a cervical tumor and an improperly fixed biopsy specimen was erroneously interpreted as showing Hodgkin's disease



Fig 4. Case 2, Lorraine L Delay in diagnosis in a case of epidermoid carcinoma of the pharyngeal wall in a patient complaining only of a cervical tumor An erroneous clinical diagnosis of Hodgkin's disease was made at first.

base of the tongue was bulky and could have been discovered readily by inspection or even by the exploring finger The avoidable delay in diagnosis was about 3 months

CASE 5 Delay in diagnosis in a case of epidermoid carcinoma of the nasopharynx in a physician who complained only of cervical swelling

John R, male, aged 49 years, the assistant superintendent of a tuberculosis sanatorium, was first seen by one of us (H M) in August, 1941 In January, 1941 he had suffered a severe upper respiratory infection which subsided and he returned to his work In March, 1941 he had suffered another severe upper respiratory infection which was associated with marked bilateral enlargement of the



Fig. 5

Fig. 5. Case 3, George P. Una. Obtainable delay in the complete diagnosis in case of adenocarcinoma of the base of the tongue in patient complaining only of cervical tumor for period of 8 months.



Fig. 6.

Fig. 6. Case 4, John T. Delay in diagnosis in case of carcinoma of the base of the tongue in patient complaining only of cervical mass the diagnosis of which was missed because no examination of the mouth was made.

cervical lymph nodes. It was noted that this lymph node enlargement did not recede when the infection subsided. He was assiduously attended and examined by the staff of the tuberculosis sanatorium who were of the general opinion that the lymph node enlargement was tuberculous in character. The consensus was that he should wait for these nodes to calcify and then have them removed. The cervical swellings progressively enlarged and finally one of his associates urged him to have further investigation made.

After delay of 8 months from the beginning of symptoms, the patient came to New York for consultation, and bulky, bilateral lymph node enlargement, clinically typical of metastatic cancer was noted. From the position of the lymph nodes in the upper neck, the nasopharynx was suspected as the site of the primary lesion and examination hastily disclosed bulky tumor at least 3 centimeters in diameter on the posterior wall. A biopsy from this lesion was reported as epidermoid carcinoma, grade III.

In this case, the association of ideas, that is of enlarged cervical lymph nodes and tuberculosis was a natural one since the patient and his colleagues were on the staff of a tuberculosis sanatorium. The clinical diagnosis of tuberculosis, unsupported by histologic evidence was persisted in for about 8 months until the disease progressed to an advanced stage. The patient died 2 years later from widely disseminated cancer. The probably

avoidable delay in diagnosis in this case was about 8 months.

CASE 6. Delay of 8 months in diagnosis in case of epidermoid carcinoma of the nasopharynx in patient complaining only of cervical nodes.

Russell S. male aged 35 years, was first seen by one of us (H. M.) in February, 1943. He stated that he had first noticed "swellings" in both sides of the neck about 8 months previously. He had immediately consulted his family doctor, who referred him to a surgeon who performed an incisional biopsy. The pathologist returned report of "lymphoproliferation." A single examination of the upper respiratory and alimentary tracts by a nose and throat specialist was said to have been negative for any primary tumor. A specimen for biopsy was taken from the left tonsil, which showed only "infected tonsillar tissue." So far as the patient knew no further examination was made of the mouth or pharynx. He was given series of ray treatments to the neck with some regression. Six months later there was further growth of the cervical tumors and more ray treatments were given, this time with little effect. During the fall of 1943 the cervical tumors increased in size and ulcerated through the skin in the subaxillary region, and he remained for some months under the care of his local physician.

At the first consultation by one of us (H. M.) in February, 1943 the patient had no complaint except of the ulcerated cervical tumors. Physical examination revealed widespread subcutaneous tumor in both sides of the neck. In the left subaxillary region, the tumor had ulcerated and fungated through the skin over an area 5 x 6 centimeters in diameter.

Although the patient had complained of no pharyngeal symptoms, examination of the nasopharynx immediately disclosed an ulcerated, fungating lesion at least 2.5 centimeters in diameter on the left lateral nasopharyngeal wall. Specimens for biopsy were removed from the nasopharyngeal tumor and from the ulcerated lesion in the neck. Both were diagnosed by the pathologist as "anaplastic epidermoid carcinoma." The growth was considered too far advanced for curative treatment. The patient died of his disease in March, 1943.

The primary tumor in the nasopharynx might have been obvious or it might have been too small for discovery at the time of the first examination. The true diagnosis of cancer was suspected and confirmed by removal of a cervical lymph node in 1941. So far as could be learned, no systematic attempts were subsequently made to discover a primary lesion, although two series of x-ray treatments were given at intervals of about 6 months. A bulky, primary lesion in the nasopharynx was first disclosed only 7 weeks before the patient's death. The avoidable delay in diagnosis in this case was probably about 18 months.

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EXPERIMENTALLY INCREASED BLOOD SUPPLY TO THE HEAD AND NECK OF THE FEMUR

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MANY of the pathological disturbances of the hip joint are initiated or accompanied by diminution of the normal blood supply to the head of the femur. The principal nutrient arteries in the ligamentum teres or the posterior capsule of the joint become thrombosed or lacerated and since they are endarteries with little collateral circulation, the nutrition of the head is impaired. The resultant avascular (or "aseptic" or "quiet") necrosis of the head of the femur may be seen in such conditions as fracture of the neck of the femur, traumatic dislocation of the hip, Perthes disease, slipped epiphysis or monarticular hypertrophic arthritis, and, while each infirmity has distinctive clinical signs and symptoms, collectively they possess the common characteristic of an inadequate circulation to the femoral head. On the basis of animal experiments, we have devised an operation for overcoming this localized ischemia and for hastening revascularization in case the necrosis of the head is already present.

In other regions of the body, supplementary circulation to overcome localized ischemia has been successfully provided by transplanting a flap of vascular muscle or omental tissue to the area involved. In experimental animals, we have developed a similar method of transplanting a muscle flap to the neck of the femur in such a way that an auxiliary blood supply can be directed into the neck and head of the femur. This was undertaken because bone which has suffered impairment of normal circulation is not as capable of establishing collateral circulatory paths as are other more vascular tissues and the head of the femur

normally receives only a minimal amount of blood.

Since their first reports in 1915 Claude Beck and his coworkers have shown that a pedicle graft of pectoral muscle can be transplanted to the wall of the heart in such a way that anastomoses readily develop between the vascular beds of the graft and the heart wall. In cases of coronary sclerosis, wherein the blood supply to the myocardium is impaired, transplantation of such a muscle flap is followed by marked relief of symptoms. Moreover, Beck demonstrated in experimental animals that blood vessels will penetrate the heart wall across a bridge of adherent scar produced by powdered asbestos as well as through flaps of transplanted skeletal muscle.

In experimental animals O'Shaughnessy transplanted a large graft of omentum through the left leaf of the diaphragm to the heart wall and demonstrated a vascular connection as promptly as 3 weeks after the operation. This was an adaptation of the old Morrison epiploxy operation for the relief of ascites wherein a flap of omentum was transplanted into the muscles of the abdominal wall.

Friedbacher has reported similar experiments in which transplantation of a flap of omentum to the heart wall was followed by the establishment of a rich anastomosis of blood vessels.

Heinbecker and Barton were able to produce a collateral circulation to the heart wall by introducing an irritative material into the pericardium which resulted in adhesive pericarditis. These adhesions were shown to convey small vascular anastomoses into the myocardium.

German and Taffel applied pedicle grafts of temporal or occipital muscle to the brain in monkeys and identified communicating blood vessels from the muscle flap into the cerebral cortex.

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Fig 1 Specimen from experimental animal 2 months after muscle flap transplant to anterior surface of the neck of the femur

Kredel reported 3 cases in which a flap of temporal muscle was transplanted to the dura in cases of cerebral thrombosis. He recommended the operation for conditions in which there is localized ischemia of the cerebral cortex.

In an effort to augment the circulation to the kidneys, various operations have been reported which utilize flaps of omentum transplanted to the external surface of the kidney (Davis et al, MacNider et al, Mansfield et al).

ANIMAL EXPERIMENTS

In our experiments, we operated upon 28 dogs and transplanted various types of pedicled muscle flaps to the hip to try to establish new vascular connections. Mongrel city pound dogs were used and the animals were of all ages from very young pups to old dogs. The animals were anesthetized with intravenous veterinary nembutal and the usual aseptic



Fig 2 Cross section of neck of femur in experimental animal 3 months after muscle flap transplant into defect created in anterior aspect of the neck.

precautions observed. The right hip was operated upon in each case so that a comparison could be made with the normal left hip when the animals were injected at autopsy. When the dogs were sacrificed, the abdominal aorta was divided and a cannula ligated in the distal portion. The inferior vena cava was then opened and the blood vessels of the distal half of the body were flushed with normal saline solution. Immediately the vessels were injected with some radiopaque material such as lipiodol, sodium iodide, or metallic mercury after which roentgenograms were made. The comparative number of blood vessels to each hip could not be distinguished clearly enough to rely on this as an accurate method of appraisal. In one group of animals, the abdominal aorta was injected with India ink so that the capillaries to each hip could be dissected. We found, however, that the most reliable observations were those which were based on the pathological study of sections of tissue taken through the region of the muscle transplant.

In the first type of operation, a hole was drilled from the lateral side of the greater trochanter through the neck and into the head of the femur. A flap of the gluteus medius muscle was then freed and transposed so that the cut end of the muscle projected into the hole in the trochanter. It was anchored by fine wire sutures.

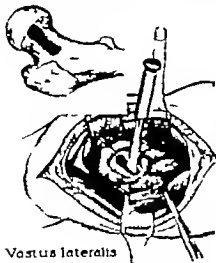


Skin incision Vastus lateralis m.

Fig. 3 Diagram illustrating operative approach; the hip block has been used for performing muscle flap transplant operation.

In the second type of operation a wider apposition between the muscle flap and medullary cavity was secured by removing the lateral cortex of the greater trochanter so that the flap of the gluteus medius muscle could be anchored directly against a large area of cancellous bone.

In the third and most successful type of operation a flap of the vastus lateralis muscle was sutured in a longitudinal slot on the an-



Vastus lateralis

Fig. 5 Diagram of method of preparing slot on the anterior surface of the neck of the femur to receive the muscle transplant.

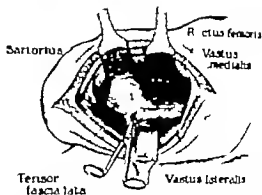
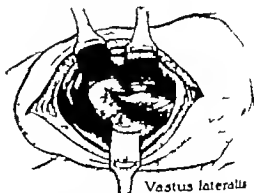


Fig. 4 Diagram showing dissection of flap of vastus lateralis muscle in preparation for transplantation to the femoral neck.

terior surface of the neck of the femur. In this way the vascular muscle tissue was transplanted directly to the neck and base of the head of the femur.

After these operations, the dogs usually protected the involved leg for 5 or 10 days after which they ran about normally with no apparent pain or limp. They were sacrificed at intervals varying from 1 week to 4 months after the operation and tissue was removed from the region of the transplant for pathological study.

After decalcification *in vacuo* by Wilson technique the sections removed from the site



Vastus lateralis

Fig. 6 Diagram showing flap of vastus lateralis muscle sutured into the slot in the femoral neck by means of sutures through the capsule and adjacent ligaments.

of the transplants were stained with hematoxylin and eosin and studied by Dr Henry Hartmen, pathologist to the Medical and Surgical Hospital

He reported "It was possible to demonstrate blood vessels effecting a direct connection between the perimysium of the striated muscle and periosteum. The line of growing capillaries was distinctly seen extending from the interstitial tissue of the muscle into the periosteum. The vascular reaction in the periosteum and underlying bone provoked by the experimental measures carried out was seen in sections of a high percentage of the specimens. Vascularized fibrous connective tissue connections showed the establishment of an intimate union between the muscle implants and the adjacent bone."

CLINICAL APPLICATION

Since our observation of this type of operation on 28 dogs disclosed that an accessory blood supply could be directed into the hip and since muscle transplants had been shown to convey blood vessels to other portions of the body, we decided to utilize this muscle flap transplant in conditions in which the blood supply to the hip was impaired as the result of disease or injury.

To date, the most useful manner in which this operation has been adapted is in cases of monarticular hypertrophic arthritis and slipped femoral epiphysis. We have been doing a muscle flap transplant to the neck of the femur at the time a vitallium cup arthroplasty was performed for the former condition and in the latter cases when a vitallium Smith-Petersen nail was inserted. Thus far in our observations, we have observed much less persistent pain after cup arthroplasties for hypertrophic arthritis and more rapid fusion of the head and neck when slipped epiphyses are nailed. It is too early to give a final appraisal of these results.

SUMMARY

Muscle flap transplants have been shown by various experimenters to convey accessory circulation to regions of the body involved in impaired vascularity.

Our experiments on 28 dogs revealed that a muscle flap transplant to the neck of the femur directs new blood vessels into the neck and head of the femur.

Many of the common noninfectious conditions of the hip result from, or are aggravated by interference with the normal blood supply to the head of the femur. Correction of this deficiency by an accessory blood supply to the neck of the femur may result in decrease of symptoms and more rapid recovery of normal hip function.

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BACTERIAL FLORA OF FRESH ACCIDENTAL WOUNDS

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DURING war the problems of wound healing are of the utmost importance to both military and civil surgeons. The great increase in the number of industrial and military wounds again emphasizes these problems. After the arrest of hemorrhage and management of shock the successful treatment of wounds depends largely upon the prevention and control of infection. Failure may result in death, loss of limb or prolonged or permanent disability. If infection does develop within the wounds further destruction of tissue occurs and the process of wound healing is suppressed. The usual traumatic wound presents many possibilities of infection. Bacteria from many sources may be introduced into the wound and may propagate and infect the wound in the presence of devitalized tissue or foreign bodies such as dirt, clothing, missiles and metal or wood fragments. While it is true that the presence of bacteria *per se* in a wound may not determine the development of infection, the most logical approach to many of the problems of wound infection rests in a knowledge and understanding of the types of bacteria contaminating wounds. As an example, recognition of the presence of *Clostridium tetani* in infected war wounds led to the development and prophylactic use of tetanus antitoxin to prevent effectively the dreaded and fatal complication of tetanus. Bacteriologic studies of accidental wounds complicated by gangrene, cellulitis or abscess have indicated the nature of the infecting agents and concentrated our attention and efforts toward their control. In our opinion further bacteriologic studies of fresh accidental wounds will undoubtedly aid in the solution of many of the remaining problems of wound infection either directly or indirectly. Additional information is needed regarding the virulence of bacteria, their biochemical requirements for growth and infection, the chemical nature of

their toxins and enzymes, and the various chemotherapeutic agents which may successfully retard their growth.

MATERIAL

At the Cincinnati General Hospital a study of the bacterial flora of fresh accidental wounds was started in April, 1941 and 99 wounds were studied in the following 10 months. The injuries consisted principally of extensive lacerations and compound fractures. Smaller numbers of human bite, dog bite, gunshot, stab and burn wounds were also included. Most of the wounded patients required hospitalization.

TABLE I

Type of wound	Location
Laceration or avulsion	11
Compound fracture	89
Human bite	
Dog bite	4
Gunshot (soft tissue)	3
Stab	4
Burns	1
Total	99

In addition to the 3 soft tissue wounds caused by gunshot there were 3 compound fractures produced by bullets. Many of these cases were street or automobile accidents and were visibly and grossly contaminated. The majority of the cases were seen 3 or more hours after injury, unlike those of Pulaski, Meleney and Spaeth which were seen within one-half hour. Previous to their admission most of our patients had not had application of either antiseptic solution or dressing.

METHOD

We agree with Meleney that a true index of the type and degree of bacterial contamination can be obtained only by culturing all tissue excised from a wound. In this way the micro-organisms contaminating the surface as well as those deposited in the deeper recesses of the wound are more likely to be detected by cultivation. Material obtained for

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culture by swabbing the wound surface frequently is not a representative sample and is therefore often inadequate. Accordingly, in every instance but one the material cultured by us consisted of all the devitalized tissue excised from the wound. This tissue was placed immediately into tubes of preheated and cooling Rosenau's brain dextrose broth and milk medium. For the rapid preliminary detection of *Clostridium welchii* (1), the milk medium tubes were incubated for 24 hours under anaerobic conditions produced by Wright's modification (17) of the pyrogallic acid technique, Rockwell's solution being used (18).

After incubation of the brain broth culture at 37 degrees C for 24 hours, a representative sample of it was used to make two blood agar plates for isolation of the various types of bacteria. One plate was incubated aerobically and one anaerobically, the McLeod apparatus being used. Isolated colonies were picked from the aerobic plates within the first 24 to 48 hours, and from the anaerobic plates were 10 days. Additional anaerobic plates were made from the brain broth cultures after 7 days' cultivation to catch any slowly developing anaerobic bacteria. During the study it became apparent that it was necessary to hold the brain broth cultures and anaerobic plates for 5 to 10 days to obtain satisfactory growth of such anaerobes as *Clostridium tetani* and *Bacillus melaninogenicus*. After isolation of the bacterial strains, their identification was completed whenever possible by morphological and cultural studies.

RESULTS

Bacteria were cultured from all but 4 of the 99 wounds studied. In at least 2 of these 4 instances we believe that a false negative culture was the result of an old faulty incubator which became too hot. In these 2 cultures bacteria were seen in a stained smear, although no growth was obtained on subcultivation.

From 1 to 8 different species of bacteria were cultured from each specimen of debrided tissue, the average being 3.2. Pure cultures were found to be present in only fifteen instances.

TABLE II

Strains	Incidence %
101	86
61	54
20	20
39	39
7	6
11	11
8	8

Bacterial types
Staphylococci
Streptococci
Enterobacilli
Clostridium welchii
Other clostridia
Bacteroides
Anaerobic and microaerophilic streptococci

Eighty-six per cent of the wounds were contaminated with 101 strains of viable staphylococci. Of these strains 37 were hemolytic and 64 were nonhemolytic. Unfortunately during the first part of this study we did not classify these staphylococci as to their ability to coagulate human plasma. More recently we have found that approximately 20 per cent of the hemolytic strains isolated from this source were coagulase positive varieties (5). Hemolytic staphylococci were found in 37 per cent of the cases, being rather evenly distributed throughout the various types of wounds. Fifty-four wounds were found to be contaminated by 61 viable strains of aerobic streptococci. Of these 13 were hemolytic, 33 nonhemolytic, and 15 green producing.

TABLE III

No. and type of wound	Incidence of staphylococci	
	Hemolytic	Nonhemolytic
35 Lacerations	10	28
29 Compound fractures	9	19
11 Human bites	5	5
4 Dog bites	2	1
3 Gunshot	1	2
4 Stab	2	7
13 Burns	8	—
	37	64

Clostridium welchii was found in 39.4 per cent of the fresh accidental wounds as is shown in Table IV. This organism was present in 30 per cent of the soft tissue wounds, in 38 per cent of the compound fractures, and in 85 per cent of the burns. The last 24 strains of *Clostridium welchii* isolated from these wounds were tested for animal pathogenicity. Subcutaneous inoculations of 0.5 cubic centimeters of a 24 hour brain broth culture were made in the abdominal wall of guinea pigs. In every instance an area of crepitant cellulitis developed, but the size and extent varied considerably with the various

strains. Gangrene and ulceration were caused by 22 strains and death of the animals by 24

TABLE IV

No. and type of wound	Incidence of <i>Clostridium welchii</i>
15 Lacerations	
30 Compound fractures	
Human bites	5
4 Dog bites	
3 Gunshot	
4 Stab	
3 Burns	
	39-50 per cent

Clostridium tetani was isolated in 2 instances from a compound fracture and from a deep laceration. Both strains were toxicogenic.

ANALYSIS OF STUDY

There is still considerable dispute over the question of whether or not all accidental wounds are contaminated by bacteria. Many reports give an incidence of negative wound cultures of from 7 to 41 per cent. Veruut and Drenth found that 41 per cent of the wounds studied were sterile. Dimitza and Gutscher found 21.7 per cent. Levaditi (9) found 7 per cent. Miles et al. found 9 per cent and Hare (7-8) found 11.1 per cent. An analysis of these studies indicated that the specimens cultured were often obtained from swabs of wound secretion and not from debrided tissue. On the other hand, the reports of Sas, and Pulaski, Meleney, and Spaeth (15) indicate that all accidental wounds are contaminated. For all practical purposes we believe that all accidental wounds, particularly extensive ones, are contaminated to some degree by bacteria.

In this study the bacterial flora of wounds was mixed and varied. From 1 to 8 different species of bacteria were cultured from each wound. Pure cultures were found in only 5 instances.

Two general types of bacteria contaminated these fresh wounds, one consisting of those of intestinal origin, and the other of those originating from the human upper respiratory tract, skin, and infected wounds.

The first group consisted of both aerobic and anaerobic intestinal bacteria which reached the wound either directly through

contamination by feces or indirectly by fertilized soil or wool clothing (2-6-11). In addition to other intestinal bacteria, cultivated and polluted soils may contain as many as 10,000 *Clostridium welchii* spores per gram of soil (21). This group included the more important anaerobes such as *Clostridium welchii*, and others of the gas gangrene group, *Clostridium tetani*, *Bacteroides*, and anaerobic streptococci. Of lesser importance were the aerobes such as *Bacillus coli*, *Bacillus aerogenes*, *Bacillus proteus*, *Bacillus alkaligenes*, and the enterococci. In general the pathogenicity of members of this group was low but the presence of devitalized tissue greatly enhanced their virulence.

The second group was composed of staphylococci and streptococci either aerobic, anaerobic, or microaerophilic. The majority of these bacteria were also of low virulence for experimental animals in pure culture but certain hemolytic varieties were particularly pathogenic. The sources of these bacteria have been shown (7-8-13) to be the human respiratory tract, the skin of patient or personnel treating the wound, and the air or instruments contaminated by nearby infected wounds. Wound contamination by this group may produce cellulitis, abscess, lymphangitis, osteomyelitis, ulceration, bacteremia or septicemia.

In this study there was a rather high incidence of hemolytic staphylococci and hemolytic streptococci contamination of fresh wounds. Because of the nature of this hospital and of its accident patients, a large number of unmasked persons may come into contact with a wound including individuals administering first aid, police receiving ward personnel as well as nurses, physicians, and medical students. One out of every 3 wounds in this series was already contaminated by hemolytic staphylococci and 1 out of every 8 by hemolytic streptococci at the time the patient reached the treatment or operating room. It seems evident that in hospital practice secondary contamination of open wounds by pyogenic cocci has often occurred before definitive treatment is begun. This observation is the strongest argument we know for the application of a sterile gauze dressing to

all wounds at the earliest opportunity and for the masking of patient and personnel whenever this dressing is removed. Further cross contamination and secondary hospital infection as recently emphasized by Miles and Hare (7, 8) were also seen in subsequent observations of these cases.

The contamination of 39.4 per cent of the wounds by *Clostridium welchii* is a higher incidence than that described by Sas (14.5 per cent), Dimitza and Gutscher (20 per cent), Levaditi et al (17 per cent), Pulaski, Meleney, and Spaeth (11.9 per cent), Miles et al (16 per cent). However, over three-fourths of the 99 wounds studied were extensive, visibly dirty, and three or more hours old. Each of these factors tends to increase the incidence of clostridial contamination. The absence of visible dirt does not rule out the presence of *Clostridium welchii* by any means, for it was cultured from several apparently clean lacerations and from 5 human bite wounds. The high incidence of *Clostridium welchii* in burns (86 per cent) was particularly interesting and unexpected and the burned tissue was also found to be grossly contaminated by a large number and variety of other bacteria.

The high degree of wound contamination by anaerobic bacteria suggests certain limitations and dangers in the treatment of compound fractures by the Orr-Trueta closed-plaster method. Gangrene may result from pressure and it would seem that unpadded plaster encasement of an extremity should be used only when constant close supervision is possible for at least 24 hours. Many anaerobes are noted for their tendency to burrow and dissect through the subcutaneous and subfascial tissues. In the presence of anaerobic bacterial contamination and residual devitalized tissue resulting from incomplete or inadequate débridement, it is difficult to believe that infection would be prevented simply by reduction of the fracture and prolonged application of a cast. Such doubts seem to be confirmed by the observations of Arnaud and his associates on 600 men wounded in the Spanish Civil War. All had been treated by the closed-plaster method from 15 days to 6 months before. Half of the compound fractures showed mediocre results as evidenced

by malunion, nonunion, and infection. All fractures of the femur showed bad results and no wounded joint was without complicating infection. Although many cases demonstrated no clinical signs of infection, many had infective dissection of the subcutaneous and subfascial layers, particularly of the lower extremity. Several cases with similar results treated by this method at the Cincinnati General Hospital have been observed.

SUMMARY AND CONCLUSIONS

Analysis of the results of this study and a review of the recent literature on the bacterial flora of accidental wounds show several significant observations.

- 1 All war wounds and, in all probability, all accidental wounds are contaminated by bacteria by the time they are seen by a surgeon.
- 2 The bacterial flora of wounds is mixed and varied. Many different types of bacteria may be found contaminating wounds singly or in combination.
- 3 The bacteria fall into two main groups, an intestinal group and a pyogenic group. The sources of the former may be human or animal feces, soil, or clothing. The latter originates from the human sources such as the respiratory tract, skin, or other infected wounds.
- 4 Contamination by the pyogenic group seems to occur in a small proportion of cases at the time of injury, but in a much greater proportion after the time of injury. A considerable degree of secondary pyogenic contamination may occur by the time a surgeon sees a wound of three to six hours' duration. The importance of covering a wound immediately by the application of a sterile dressing is obvious.

- 5 The high degree of anaerobic bacterial contamination emphasizes the danger of closing extensive wounds, particularly compound fractures, unless careful and skillful débridement is possible. Even with apparently careful and time-consuming débridement, we have seen fulminating gas gangrene develop in civil practice in wounds that were closed. Early diagnosis of such anaerobic infections depends largely upon close observation of the wounded extremity, particularly when it is in a cast.

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A SIMPLE, USEFUL ANTERIOR GASTROENTEROSTOMY

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IT has been said that there is always a tendency to make progress by exaggeration. Certainly this was true some years ago in the universal application of gastroenterostomy in the treatment of peptic ulcer, both gastric and duodenal. So enthusiastic were some surgeons that its successes were overstressed and its failures and complications underestimated.

With realization of the high percentage of patients with gastrojejunal ulcer and gastrojejunocolic fistula following gastroenterostomy, surgeons have turned from gastroenterostomy to the newer procedure, subtotal gastrectomy. They now are prone to have the same or even greater faith in its unreserved use, with the conviction that it offers better results than gastroenterostomy because of lower gastric acid figures and fewer gastrojejunal ulcers and gastrojejunocolic fistulas after operation.

In a recent paper on the management of the complicated peptic ulcer, Dr S F Marshall and I agreed in general with this position. However, certain ulcers are so low in the duodenum that they either are fused with the common bile duct or located, more rarely, below the level of entrance of the common duct into the duodenum, so that removal requires severance and reimplantation of the bile duct into the duodenum at a lower level. This in itself would not be such a forbidding procedure except for the complicating problem of the adjacently entering pancreatic duct. We have handled such cases successfully by implanting the head of the pancreas into the side of the jejunum, as in partial removal of the pancreas for cancer, however, the procedure is of such magnitude that, under the circumstances, gastroenterostomy, even with its possible 15 per cent incidence of gastrojejunal ulcer, is a better procedure than partial gastrectomy.

In addition, there never has been any question about the satisfactory results of gastro-

enterostomy for cicatricial pyloric obstruction, since this occurs only in the presence of a healed ulcer. In such mechanical pyloric obstruction by scar tissue, the gastric acids are low, otherwise healing would not occur. The stomach is dilated and easily handled, and the symptoms are only those of obstruction to the passage of food past the cicatricially stenosed pylorus.

Further, in addition, an occasional patient with a duodenal ulcer that is intractable to medical management is unsuitable for subtotal gastrectomy because of an associated condition, such as hypertension, a poorly compensated cardiac lesion, an asthmatic state, bronchiectasis, or even obesity.

In the treatment of over 7,000 ulcer patients in the clinic under hospital management, we have encountered practically every possible ulcer problem, both surgical and non-surgical. As a result of this experience, we are convinced that, even accepting the minimum of 15 per cent of postgastroenterostomy stomal ulcer, gastroenterostomy is sometimes preferable in those cases to the more hazardous subtotal gastrectomy. The reasonable efficacy of gastroenterostomy in relieving patients of ulcer symptoms is indisputable, but the wisdom of the procedure is questionable because of the frequent occurrence of a post-operative stomal ulcer that is intractable to medical management and technically difficult to handle surgically.

With these facts in mind concerning this particular group of bad risk ulcer patients, I have for many years willingly accepted for them a less desirable operation with a lower mortality rate because I prefer a live patient, even if he develops a stomal ulcer, to a patient with an acceptedly better operation who, because of the high mortality rate, is less likely to have a stomal ulcer. It is not my purpose to be facetious about such a serious subject as a fatality but rather to emphasize the necessity of balancing desirability against mortality rate in an operative procedure.

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Having established this position I wish to segregate the factors involved in this problem and to weigh them individually and collectively. First gastroenterostomy would be a good operation were it not for the stomal ulcers. Second gastrojejunal ulcer and gastrojejunoileic fistula are of much higher incidence than formerly was assumed. Third, these recurrent stomal ulcers are difficult to handle surgically and consequently have a relatively high mortality rate.

An analysis of these facts, which almost every surgeon would accept simplifies the problem and facilitates recognition of important points in it. Let us put the incidence of stomach ulcer following gastroenterostomy well above that already established say 30 per cent. That leaves 70 per cent of patients with fairly good results, which is far from undesirable provided gastroenterostomy can be made safer provided subtotal gastrectomy can be avoided in patients with ulcers located low or fused with the bile duct provided many conditions that often make gastroenterostomy technically difficult can be eliminated and provided a secondary subtotal gastrectomy can be made easier should a stomal ulcer occur. It is important to mention that we commonly employ subtotal gastrectomy for patients with peptic ulcer and that the type of gastroenterostomy herein discussed is limited to those patients in whom because of complicating features, subtotal gastrectomy appears unduly hazardous.

Since I am constitutionally a nonconformist and am unimpressed with the sanctity of ideas I always was skeptical about the desirability of the so called no loop posterior gastroenterostomy. This particular method, which is one of the factors which makes secondary subtotal gastrectomy for stomal ulcer difficult and acridous, originally was designed to overcome the alarming so called vicious circle vomiting which sometimes followed certain gastroenterostomies. Most of these complications were related not so much to the way the loop was put on (what multitudes of pages have been written about how to place stomas!) but rather to the fact that with long loops twisted applications and obstructive adhesions were possible. The real contributions in the principle

of the no loop gastroenterostomy are that the proximal jejunal loop is so short that it is almost impossible for the surgeon to get it onto the stomach wrong. If he can get it on at all, and that obstruction seldom occurs. No loop posterior gastroenterostomy is a difficult way to do an easy operation, and if a postoperative stomal ulcer develops, subtotal gastrectomy is unnecessarily difficult and dangerous.

What surgeon with a large experience with gastric surgery has not had difficulty in doing a posterior gastroenterostomy in a patient with a short fat mesocolon? What surgeon has not had most annoying difficulties in pulling through the opening in the root of the transverse colon mesentery an adequate amount of high nondeliverable stomach in order to do a gastroenterostomy of adequate size without clamps, much less get a stoma of sufficient size with gastroenterostomy clamps. What surgeon has not been dissatisfied with the size of the stoma, the safety of the suture line and the accuracy of the application of the loop and stoma in completing a no loop posterior gastroenterostomy in a fat patient, a poor anesthetic subject with a fat filled mesentery and a high, small, nondeliverable stomach.

The most objectionable feature of a no loop posterior gastroenterostomy in my opinion, is that an anastomosis which will not leak and will control bleeding has to be done high up in the jejunal loop behind the colon where anatomic relations with the stomach held up, are reversed and where good exposure is often difficult if not impossible.

These features make recurrent stomal ulcer difficult to manage by subtotal gastrectomy following no loop posterior gastroenterostomy. When a gastrojejunal ulcer does occur under such conditions, the induration about the ulcer often involves the root of the mesentery of the transverse colon and even at times includes the middle colic artery. The induration often involves the jejunal stump and makes safe resection of the short proximal jejunum difficult. In addition, if complete resection of that portion of the jejunum which forms the gastrojejunal stoma is necessary rather than partial removal of the bowel wall, the proximal intrapentocolic jejunal stump is often so short that

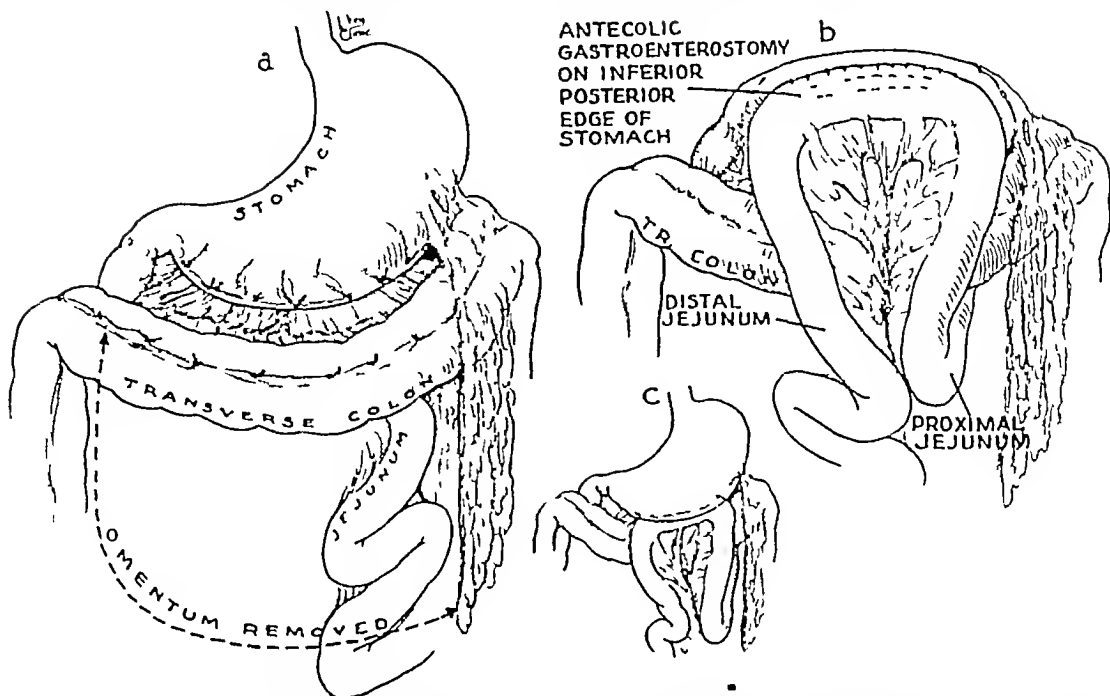


Fig. 1 a, The omentum is removed well over onto the left side of the greater curvature. The greater curvature is completely free and is easily lifted up. b, The greater curvature of the stomach is held up in a Babcock clamp (not shown), and the jejunum is attached to it just behind the greater curvature edge. In this position the gastric contents gravitate back into the stomach, and the edge of

the stomach freed of its omental attachments can be lifted well up into vision and the anastomosis can be done without clamps or tension. With this mobilization there is no limitation as to the size of the stoma. c, The stomach is in position and the stoma is completed. Note the absence of any jejunojejunal anastomosis between the efferent and afferent loop in this procedure.

a lateral jejunal anastomosis is impossible and an end-to-end one difficult. In such high anastomoses the jejunal anastomosis can also slip under the vascular mesenteric root and become obstructed. The surgeon should also keep in mind that because the jejunum as it approaches the ligament of Treitz has such a short and meager mesentery, any interference with it easily results in loss of blood supply to the jejunal stump and a black bowel which will require still higher resection. Such complications as this prompted me to devise the retrocolic mobilization of the high jejunum to the left of the vascular mesenteric root (1).

ANTERIOR GASTROENTEROSTOMY

Because of these objections, I often have performed an anterior rather than a posterior gastroenterostomy. However, not until I had evolved the procedure herein described was I satisfied with the ease and safety with which it

can be performed even in those patients with a high, nondeliverable stomach and a fat-filled mesentery, and the way in which it functions postoperatively.

In spite of statements to the contrary in this country and abroad, it was my conviction that an antecolic Hofmeister or Pólya operation would function as satisfactorily as a posterior anastomosis of the jejunum to the resected stomach. It was my conviction that there would be fewer postoperative obstructions and failures to drain with antecolic anastomosis of the jejunum to the resected stomach than with posterior anastomosis. It was my further conviction that when an antecolic anastomosis was made, jejunojejunostomy between the efferent and afferent loop not only was unnecessary but undesirable, since it side-tracked the alkaline jejunal content of the proximal jejunal loop into the distal loop instead of permitting it to pass into the stump.

Having established this position, I wish to segregate the factors involved in this problem and to weigh them individually and collectively. First gastroenterostomy would be a good operation were it not for the stomal ulcers. Second gastrojejunal ulcer and gastrojejuno-colic fistula are of much higher incidence than formerly was assumed. Third these recurrent stomal ulcers are difficult to handle surgically and consequently have a relatively high mortality rate.

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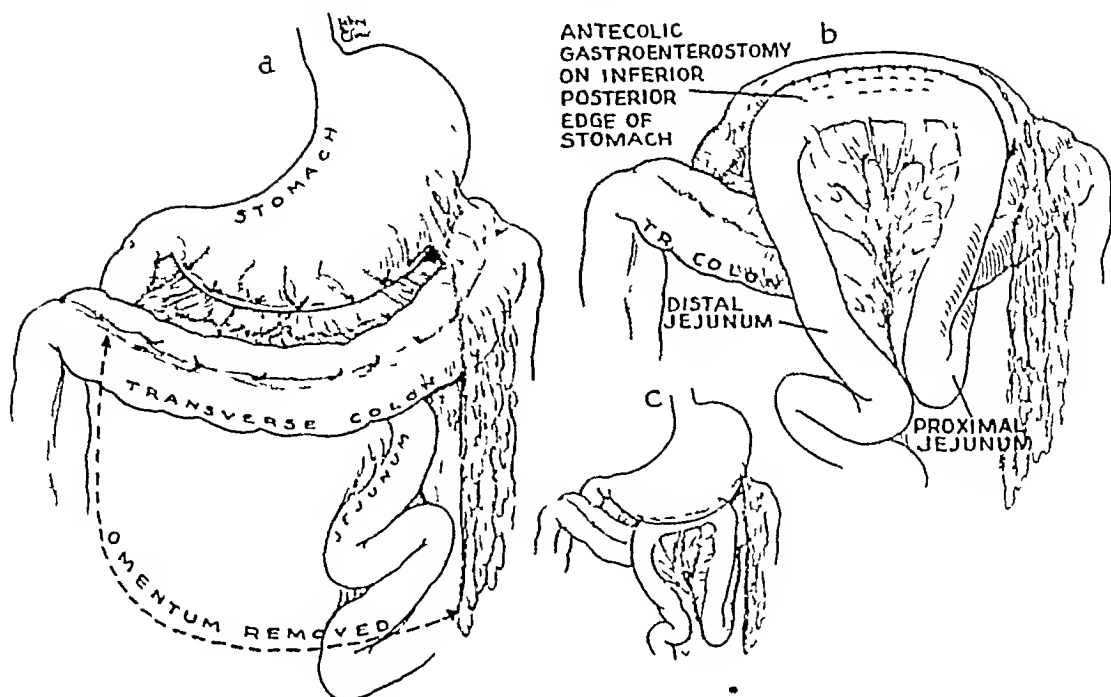


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of the resected stomach to neutralize and lower gastric acidity in the remaining gastric stump.

The soundness of these convictions is demonstrated by the fact that for several years antecolic anastomosis has been employed at the Lahey Clinic both in gastric resection for ulcer and for carcinoma without jejunofejunostomy. No obstruction, failure to drain or malfunction has occurred.

Perhaps the most severe test of antecolic anastomosis without jejunofejunostomy occurs in total gastrectomy. We have now performed total gastrectomy upon 70 patients, and in all of them the jejunum was brought up in front of the transverse colon and anastomosed to the esophagus, and in over half of them no jejunofejunostomy was done. In all patients who survived (about 75 per cent) the anastomosis has functioned satisfactorily. If such an antecolic anastomosis of the jejunum to the stump of the esophagus without enteroenterostomy will function, the surgeon need not worry about a properly performed anterior gastroenterostomy. If an ulcer occurs following subtotal gastrectomy for ulcer with an antecolic anastomosis, the case with which the problem can be handled by a further subtotal gastrectomy as compared with the difficulties encountered when the anastomosis is retrocolic is striking.

The most important single feature of this antecolic gastroenterostomy is the removal of the omentum from the greater gastric curvature from the right side over to the left of the midline (Fig. 1). From our experience with removal of the omentum in gastric resection for carcinoma, we know that this procedure is safe, simple, and quickly performed. It opens the lesser peritoneal cavity and completely frees the greater curvature of the stomach of any attachments, so that it can be picked up

in a Babcock forceps and turned upward easily. The loop of antecolic jejunum can be attached to it just behind the edges of the greater curvature, and a wide anastomosis without tension can be made under direct vision without clamps.

As the stomach is held up by the Babcock forceps while the jejunum is applied to the greater curvature just behind its lower edge the gastric contents remain within the stomach by gravity and gastroenterostomy clamps are unnecessary (Fig. 1). However I wish to repeat that the omentum should be removed well over onto the left side and high up to the left on the greater gastric curvature. The proximal loop of jejunum should be of sufficient length so that it fits easily over the transverse colon without tension. With the stomach turned up and the transverse colon freed of omentum and visualized twisting of the loop of the jejunum in its application to the stomach is practically impossible. An enteroenterostomy is unnecessary.

SUMMARY

The following points are discussed: (1) The types of ulcer cases in which gastroenterostomy is preferable to subtotal gastrectomy; (2) the difficulties resulting from recurrent stomal ulcers after posterior gastroenterostomy; and (3) the advantages of anterior gastroenterostomy particularly by making subtotal gastrectomy easier and safer when a postoperative stomal ulcer occurs.

A safe and simple type of anterior gastroenterostomy with removal of the omentum from the greater gastric curvature is described and illustrated.

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A CLINICAL AND BACTERIOLOGICAL STUDY OF PHEMEROL AS A SKIN ANTISEPTIC

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THE evaluation of skin antiseptics is a difficult problem in which to arrive at any forthright conclusions. These difficulties are magnified by the variations in techniques employed by different investigators, by the selection of bacterial cultures used for study, by the interference of secretion from skin glands, and by the addition of body fluids. Because of the variations in requirements for skin antiseptics, it is quite unlikely that any one agent will be found to be superior to all others in *all* categories of use. By varying the technique of investigation, almost any antiseptic can be shown to be superior to others.

This study has been arranged to parallel the techniques of surgery for the preparation of the skin. We believe this is a practical and impartial method of comparing the clinical usefulness of skin antiseptics.

It is the purpose of this paper to report clinical and bacteriological studies on an antiseptic from a new group of drugs, the detergents. This material studied is para-tertiary-octyl-phenyl-diethoxy-dimethyl-benzyl-ammonium chloride, marketed as phemerol. This antiseptic was studied on patients in the obstetric and gynecological wards, a modification of the technique described by Novak and Hall in 1939 being used.

METHODS

We followed the routine technique of this institution for the preparation of the abdomen for surgery. The abdomen is scrubbed with tincture of green soap and gauze, rinsed with 70 per cent alcohol, and painted with an antiseptic. In order to have a base line for comparison, we used the same preliminary cleans-

ing in this study. One half of the abdomen was then treated with the antiseptic studied, the soap and alcohol side being used for comparison, as the study progressed, the two sides of the abdomen were painted with different antiseptics for comparison. The accompanying diagram illustrates this technique. Small culture plates¹ containing blood agar were placed on the abdomen as soon as the antiseptic was dry. They were removed at half-hour intervals and incubated at 37 degrees C for 48 hours. The number of colonies was counted and the bacteria partially identified by subculture and stained smear.

No attempt was made to study all of the commercial antiseptics which are available. We selected members of the following groups: cresol-mercurials (Novak's solution and mer-cresin), the halogens (iodine), organic mercurials (merthiolate), and detergents (phemerol). It is impossible to set up exact parallels of concentration in these vastly different antiseptics. We have used the stock solutions in each case as recommended by the author and manufacturer (Novak's solution—stock tincture of mercresin—1:1000, tincture of merthiolate—1:1000, tincture of iodine—7 per cent, aqueous phemerol—1:500, and tincture of phemerol—1:500).

We also studied the effect of increased body temperature and sweating on the bacterial action of phemerol and made observations on skin irritation, clinical morbidity, and wound healing.

RESULTS

Using this technique of clinical bacteriology, we have studied a total of 1020 plates on 102 patients and have subcultured and identified over 50,000 bacterial colonies. The clinical studies were made on 300 consecutive obstet-

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¹Small aluminum plates, 16 sq. cm. surface—Eimer and Amend, N. Y.

TABLE I
Number of colonies per plate

Patient	Tincture of phenmerol					Tincture of soap and alcohol				
	1/2 hr	1 hr	1 1/2 hr	2 hr	2 1/2 hr	1/2 hr	1 hr	1 1/2 hr	2 hr	2 1/2 hr
			25	30	30	20	25	200	17	
			26	29		14	47	6	3	
						3				
							8			
		17		12	17	3		24	75	
7						43				95
6		20	14	47	30					70
	3						43	105	70	
20				18		8	175	200		
							40			8
								8	1	
									90	7
24							46	44	30	67
					6			24	71	
75		6					6	40		
14								20		
19								7		15
29						26	11	10	21	
			6							34
Total colonies	26	196	20	1,28	193	100	602	504	724	497

*Plates contaminated

neal and 100 surgical cases. In the tables will be found the results obtained in these studies.

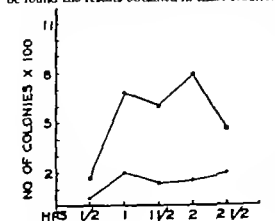


Fig. Tincture of phenmerol, ———— tincture of soap and alcohol — — — — —

In Table I is a comparison of tincture of green soap and alcohol and tincture of phenmerol. There are approximately twice as many colonies on the soap and alcohol side of the abdomen as on the phenmerol side. The bacteriostatic effect of phenmerol is demonstrated in Figure 1.

Table II presents the data of a similar study in which tincture of soap and alcohol, and aqueous phenmerol were used. Aqueous phenmerol is a slightly more effective germicide than tincture of green soap; this is more apparent in the first hour of the study. Because of the relatively poor showing with aqueous phenmerol further studies were not made.

Table III and Figure 2 compare tincture of phenmerol and Novak's solution. There are almost five times as many colonies on the Novak's solution side of the abdomen as on

TABLE II
Number of colonies per plate

Patient	Aqueous phemerol					Tincture of soap and alcohol				
	1/2 hr	1 hr	1 1/2 hr	2 hr	2 1/2 hr	1/2 hr	1 hr	1 1/2 hr	2 hr	2 1/2 hr
1	1	1	2	1	34	53	10	55	51	3
2	0	1	7	7	2	1	4	0	1	0
3	0	3	0	0	0	2	4	0	5	3
4	0	0	0	0	2	7	0	0	3	4
5	2	5	1	10	4	1	3	4	0	8
6	0	0	0	2	0	0	2	0	2	5
7	14	10	53	124	46	*	7	17	30	83
8	0	1	0	2	0	1	3	1	1	9
9	0	8	60	12	46	1	7	48	11	54
10	7	2	6	34	*	0	13	4	30	44
11	0	0	2	1	1	0	0	1	3	8
12	5	5	4	5	8	2	34	17	8	2
13	2	0	0	0	0	0	2	0	0	0
14	1	23	24	18	17	13	5	15	22	15
Total colonies	32	50	159	216	160	81	94	162	185	238

*Plates contaminated

the phemerol side. Phemerol was compared with another member of the same group, tincture of mercresin. In Table IV and Figure 3, are presented the data obtained from this study. Approximately six times as many bacterial colonies were found with mercresin as with phemerol.

Tincture of merthiolate, another of the mercurials, was also studied and figures obtained from this comparison are presented in Table V and Figure 4. Here it is seen that phemerol also has approximately a 6:1 advantage over merthiolate.

When phemerol and tincture of iodine are compared by this technique no appreciable difference in bactericidal and bacteriostatic effect could be demonstrated. These data are presented in Table VI and Figure 5.

We further studied phemerol to determine the effect of heat and sweating on its antiseptic qualities. This investigation was carried out in a heated hospital ward during the winter, thus variation in results from patient to patient caused by differences in room temperature and humidity, as might be found during the summer season of the year, were elimi-

nated. Both thighs of the patient were painted with the tincture of phemerol and a heat cradle was placed over one thigh to induce sweating. Under this technique the effect of the mixture of perspiration with phemerol on bacteria was studied, the data are tabulated in Table VII and Figure 6. Sweating does not seem to interfere with this antiseptic.

Many varieties of bacteria were found on the culture plates, of these the coccus group

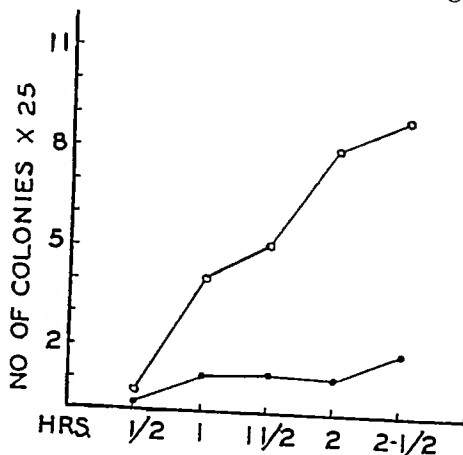


Fig 2 Tincture of phemerol ———, Novak's solution ○—○—○

*The iodine was allowed to dry and then washed off with 7 per cent alcohol. This was followed to parallel the usual surgical technique.

TABLE III
Number of colonies per plate

Patient	Tincture of phenacetol					Kosov's solution				
	1/4 hr	1 hr	1 1/2 hr	2 hr	4 hr	1/4 hr	1 hr	1 1/2 hr	2 hr	4 hr
			1	6				12	1	26
			7		10		1		1	17
		3					13			10
8										
									16	
10									20	
									1	1
11							1			1
										6
15										
17										17
18										
19							13			10
20									1	17
Total colonies			1	13	17	10	101	16	100	120

TABLE IV
Number of colonies per plate

Patient	Tincture of phenacetol					Tincture of monoglycine				
	1/4 hr	1 hr	1 1/2 hr	2 hr	4 hr	1/4 hr	1 hr	1 1/2 hr	2 hr	4 hr
					11			8	13	10
								6	14	10
										1
								13	13	10
								16		
					11		10	1	6	
					1				10	10
				14				1	100*	10
								10	10	
20									6	17
Total colonies			17	17	22	11	16	31	104	127

*1% less contaminated

TABLE V
Number of colonies per plate

Patient	Tincture of phenicol					Tincture of merthiolate				
	1/2 hr	1 hr	1 1/2 hr	2 hr	2 1/2 hr	1/2 hr	1 hr	1 1/2 hr	2 hr	2 1/2 hr
1	2	1	1	2	1	10	11	11	23	105*
2	0	0	0	1	0	0	1	1	5	4
3	0	0	0	1	0	0	2	4	5	11
4	0	0	0	4	1	0	1	2	6	
5	0	0	0	0	0	11	4	6	13	6
6	0	0	0	2	1	3	0	1	11	0
7	0	0	1	1	2	1	2	6	3	4
8	0	1	1	2		15	2	1		
9	1	1	1	1	4	6	10	5	14	10
Total mean	1	1	1	1	1 1/2	4.2	12	4 1/2	23	16 1/2

*Factor of 1000

predominated. *Streptococcus*, *Staphylococcus aureus* and *albus*, and *sarcina* were uniformly present. While no statement can be made regarding a decrease in any specific organism, it is remarkable that only three colonies of streptococci were found on all these plates and these were on 2 patients (Case 9, Table I, Case 2, Table IV). We found less *Staphylococcus aureus* than *albus*, and the *sarcina* were rather infrequently present. Several bacilli were identified, chief of which were spore formers, diphtheroids, gram-negative organisms of the colon group, and pseudomonas. An occasional mold was found. All of these organisms were quite uniformly scattered

throughout the plates and did not vary significantly with the various antiseptics studied.

Concomitantly with these studies, observations were made to determine skin sensitivity or other toxic reactions which might be attributed to phenicol when employed as an antiseptic. The skin of these patients was carefully observed for several days following its application, and no evidence of irritation, desquamation, or other reactions were noted. Phenicol was used routinely on 300 consecutive obstetric deliveries and 100 surgical cases without evidence of skin irritation. This is in contrast to high incidence of skin irritation from Novak's solution (15%) which we have

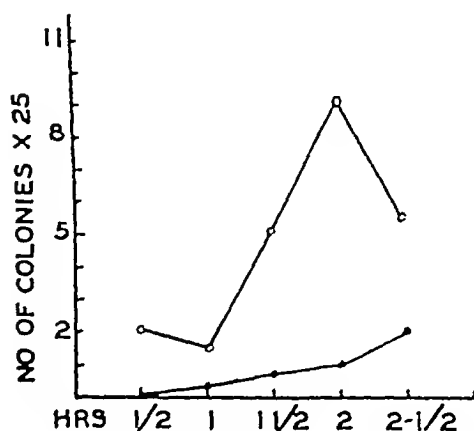


Fig 3 Tincture of phenicol ---, tincture of mercurin, o---o

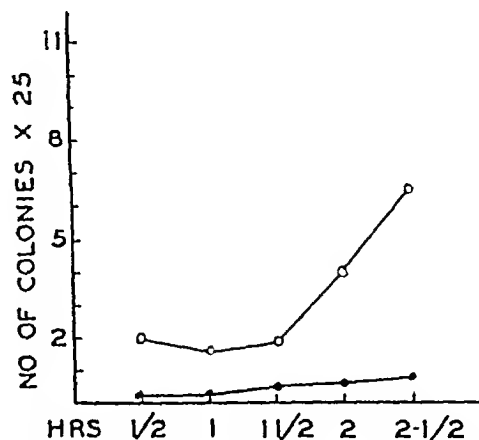


Fig 4 Tincture of phenicol ---, tincture of merthiolate o---o

TABLE VI
Number of colonies per plate

Patient	Flucture of phemerol					Flucture of iodine				
	36 hr	hr	36 hr	hr	36 hr	36 hr	hr	36 hr	hr	hr
			20						8	
									6	5
				20						
3										
6										
20					2*					
	6									
Total colonies	20		20	22	2	7		22	13	17

*1% iodine oil with 70% alcohol
 †1% iodine concentration

TABLE VII
Number of colonies per plate

Patient	Flucture of phemerol—normal thigh					Flucture of phemerol—burned thigh				
	36 hr	hr	36 hr	hr	36 hr	36 hr	hr	36 hr	hr	36 hr
6										
20										
Total colonies		9				7	3	3	3	

been using routinely in the delivery and operating rooms. Merthiolate and mercresin occasionally produced skin irritation this appeared as folliculitis.

Morbidity studies are of little or no value because of the relatively minor rôle played by the antiseptic in preventing morbidity. There was no demonstrable difference in obstetrics between this group and a comparable preceding group of cases.

No interference with wound healing was observed which could be attributed to phemerol.

We feel again that the antiseptic used plays a relatively minor rôle in wound healing, for skin antisepsis is only one of many factors involved.

RESULTS OF STUDY

A variety of criteria for the selection of skin antiseptics to be used in clinical surgery has been published (1-4). Many of these do not relate directly to the problems of the surgery. We believe that certain surgical principles cannot be compromised and require consideration. These antiseptics should (1) be free of

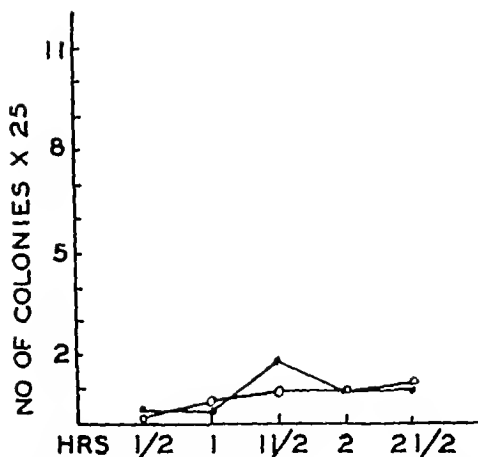


Fig 5 Tincture of phemerol — — —, tincture of iodine, —○—○—

skin irritation and toxic effects, (2) be bactericidal to pathogenic and nonpathogenic organisms found on the skin surface, (3) maintain bacteriostatic action throughout the duration of surgery, (4) not be affected by drying or contact with body fluids, (5) not interfere with wound healing. We have tried to study phemerol in relation to these criteria.

The techniques of this study are somewhat different from others reported. First, from the bacteriological standpoint, the study conditions were made to conform with the clinical procedure used in most operating rooms. The skin was first washed with tincture of soap and water and cleansed with alcohol. While this reduces the number of bacterial colonies, it does so equally on both sides of the abdomen. This preliminary cleansing is used in clinical practice and we believe this gives us a more critical base line for comparison. Second, we are comparing the two sides of the same abdomen. It is our impression that this technique permits a more accurate evaluation of skin antiseptics for clinical use than do other procedures, for it eliminates the comparison of different patients with a varying bacterial flora and degree of contamination.

From the study of the bacteria identified in this problem, it is noted that most of the bacteria usually considered pathogenic are fairly easily destroyed. *Staphylococcus aureus* and *albus* were found on plates of all the antiseptics studied, indicating that under clinical con-

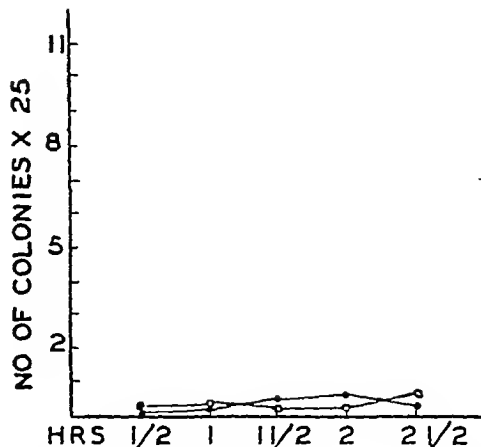


Fig 6 Phemerol on heated thigh — — —, phemerol on normal thigh —○—○—

ditions as simulated in the study, these organisms are not consistently destroyed. In future studies of skin antiseptics more attention should be paid to the staphylococcus as they exist on the skin, rather than the easily killed streptococcus, pneumococcus, and bacilli of the typhoid-colon group. These latter organ-



Fig 7 Diagram of technique. The two sides of the abdomen were used for study, one side was treated with phemerol and the other side with the substance being compared. The plates were removed at one half-hour intervals.

isms seem to be well handled by almost all of the antiseptics commonly employed at the present time.

It has been our hope to devise a technique by which we could study the penetration of antiseptics into the skin. Several unsuccessful attempts were made to precipitate antiseptic agents in the skin thereby permitting microscopic identifications of the drug. However the use of sweating gives us an approximate answer for if the bacteria in the depths of the hair follicles and sweat glands were unaffected by phemerol, we would expect a rapid rise in the bacterial count as the plates were left on the heated thigh. Since this is not true (see Table VII and Fig. 6) it suggests that phemerol either penetrated the skin glands as a bactericide, or remained an active antiseptic when mixed with perspiration.

SUMMARY

A method of studying the various skin antiseptics commonly used in surgery has been presented. This technique employs small culture plates in direct contact with the abdomen and uses the two sides of the abdomen for comparative data. The procedure simulates the conditions of clinical surgery and we

believe it is a practical and impartial method of comparing clinical skin antiseptics.

A total of 1020 culture plates from 102 patients, containing over 50,000 bacterial colonies, have been studied.

Members of the following groups of antiseptics have been studied: detergents, tincture of soap and alcohol, cresol-mercurials, organic mercurials, and halogens.

When tested by this technique tincture of phemerol of the detergent group was superior to the mercurials studied and to tincture of green soap and alcohol. It seemed about equal to tincture of iodine.

CONCLUSIONS

By the technique employed in this study we find that tincture of phemerol (1:500) (a) is a good bactericidal and bacteriostatic agent, (b) does not cause skin irritation or interfere with wound healing, (c) is suitable as skin antiseptic for use in surgery and obstetrics.

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PROTEIN DEFICIENCY IN SURGICAL PATIENTS

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SURGICAL disease is such and in addition operative procedures drain the protein deposits of the body and may produce hypoproteinemia. An extensive literature is devoted to this problem (8, 11, 12, 13, 21, 25, 26). The significance of the hypoproteinemia depends on various factors. This study, based on experiences in 278 patients deals with the following problems: (1) the incidence in the various surgical diseases before and after operation, (2) its influence on the final outcome of the disease, (3) its relation to red cell volume and protein concentration (which can be utilized as an index of the type and amount of parenteral fluid needed) and finally (4) the therapeutic results obtained by various protein sources.

METHOD AND MATERIAL

Venous blood was drawn (whenever possible without tourniquet) from each patient upon admission, and placed in test tubes containing dried heparin.¹ From the freshly mixed sample 1 cubic centimeter was withdrawn for the hematocrit determination (Wintrobe tube), another 0.2 cubic centimeter for hemoglobin determination with the photoelectric colorimeter. In the plasma of the remaining specimen density was determined by the Barbour-Hamilton falling drop apparatus (5). This method is based on the fact that the specific gravity of the plasma is chiefly influenced by its protein content. When immo reads were administered, determination of the albumen and globulin fractions were done by nesslerization (16).

Repeated determinations were made on 278 surgical patients, before and after preoperative therapy, or after operation in the 193 patients who subsequently came to surgery. In many cases (11 g. 1) samples were drawn daily, or at shorter intervals if shock or hemorrhage

was suspected. Usually, blood was drawn after intravenous fluid administration was discontinued for several hours except in cases in which continuous intravenous administration was required. The material examined is listed in Table I.

RESULTS

The average total plasma proteins for 278 surgical patients was 6.55 grams per cent with an incidence of hypoproteinemia of 22.3 per cent. Hypoproteinemia was common in patients with peptic (most often bleeding) ulcer, in carcinoma of the gastrointestinal tract, in bowel obstruction, lesions of the biliary tract, gastrointestinal fistulas, and burns.

The average total plasma proteins following surgery of the 193 patients who were operated upon dropped 5 per cent. Of the hyperproteinemic patients 30 sustained an average drop of 11.9 per cent, 118 of the normoproteinemic patients dropped 4.6 per cent and 42 of the hypoproteinemic ones showed an average increase of 4.3 per cent.

The only disease in which there was no loss attributable to surgery was peptic ulcer in 39 patients. An average rise of 0.3 per cent for the group is probably not significant. In view of the fact that in all cases but 2 these patients were subjected to subtotal gastric resection, this maintenance of plasma protein, in spite of the extensive surgery, appears significant and will be discussed at further length.

Of 58 cases of carcinoma of the gastrointestinal tract, 17, or 29.3 per cent, had average protein values below 6.0 grams per cent. This was seen more frequently in patients with carcinoma of the colon than in patients with carcinoma of the stomach or esophagus. In these patients protein deficits following surgery were considerably in excess of the general average of 5 per cent, being as much as 26.8 per cent in the cases of carcinoma of the colon.

In gall bladder disease, the only significant protein changes following cholecystectomy

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³Liquaemin.

TABLE I—AVERAGE PLASMA PROTEIN VALUES FOR 278 SURGICAL PATIENTS
RESULTS OF SURGERY IN 193

Disease	Total No. of cases	Average total protein, grams %	No. of operations	Average total protein of operative cases, %	Per cent change
Peptic ulcer	20	6.43	20	6.42	+
Carcinoma—stomach	20	6.24		6.0	
Carcinoma—esophagus		7	10	6.05	
Gall bladder disease	45	6.9	26	5.5	
Biliary carcinoma duct disease	15	6.54		6.52	
Carcinoma—colon		6.24	10	5	16.8
Peritonitis			8	6	10
Small intestine	8	5.4	10	5.25	12.7
Acute appendicitis	10		10	6.7	—
Thyroid disease	10	6.23	5	5.8	
Carcinoma—pancreas		6.0		6.06	
Gynecological conditions	10	6.95		5.5	—
Fluorid of gastrointestinal tract	10			6.4	
Burns		6.0			
Miscellaneous		6.0		5.0	
Total	278	6.0		5.5	

TABLE II.—INCIDENCE OF HYPOPROTEINEMIA (PROTEIN DEPLETION) IN 278 SURGICAL PATIENTS
INFLUENCE OF SURGERY ON PLASMA PROTEIN LEVEL

Diagnosis	Hypoproteinemia (below 5 gm. %)		Normal protein (5 to 7 gm. %)		Hyperproteinemia (above 7 gm. %)	
	Preoperative		Postoperative		Preoperative	
	No.	%	No.	%	No.	%
Peptic ulcer	12	60	20	60	17	100
Carcinoma—stomach	8.15	40	15	75	2	10
Carcinoma—esophagus	8.09	45	22	70	12	60
Gall bladder disease		64	60	100	25	77
Common duct disease		15	100	70	3	15
Carcinoma—colon			60		25	11
Peritonitis	65	100	15	100		
Small intestine	15	100	10	100	15	100
Acute appendicitis	10	100	12	100	15	100
Thyroid disease	17	100	15	70	10	100
Carcinoma—pancreas			10	100	10	100
Gynecological conditions	10		12	100	15	100
Fluorid of gastrointestinal tract		15	100	100		100
Burns					100	
Miscellaneous	10	100	12	100		
Total	20	7.95	20	100	277	100

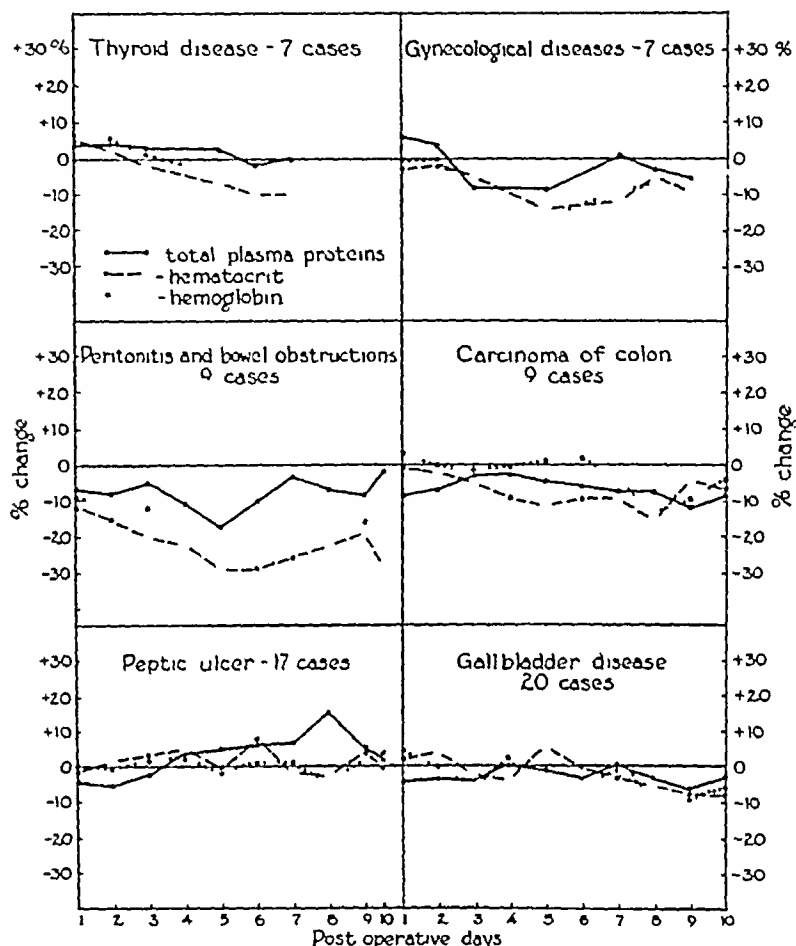


Fig 1 Consecutive daily determinations of total plasma proteins, hematocrit, and hemoglobin in 69 surgical patients following operation (Preoperative values were used as controls and the percentage daily change calculated therefrom as + (increase) or - (decrease). The value of these determinations in directing fluid therapy as well as anticipating shock and hemorrhage has proved itself. Note the relatively slight changes following thyroid and gall bladder surgery, the marked changes after surgery in cases of peritonitis and bowel obstruction, the prolonged changes in surgery of carcinoma of the colon, and the improvement following gastric resection for peptic ulcer. In the case of generalized peritonitis it would appear that greater amounts of plasma or blood than was used would have been of advantage, and that more whole blood following gynecological procedures appears to be indicated. The improvement in the cases of peptic ulcer is attributed chiefly to the large amounts of blood, plasma, and amino acids that were employed.

were seen in 6 of the 26 patients operated upon who before operation were in the hyperproteinemia range, they sustained an average 14.2 per cent drop. In only 4 was preoperative hypoproteinemia present. Our experience with benign common duct lesions was essentially the same as with gall-bladder disease.

Eight of 11 patients with generalized peritonitis showed a protein decrease of 10 per cent following surgery, none of these were within the hypoproteinemia range. In 10 of 15 cases of bowel obstruction (not infrequently associated with a peritonitis) the average plasma protein loss as a result of surgery was 18.7 per cent. Six showed a preoperative

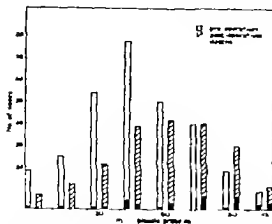


Fig. 2. Incidence of deaths according to plasma protein levels. Deaths occurred in 2 of 3 patients who either showed protein deficiencies on admission or developed them after surgery. The general trend toward protein deficit after surgery is also shown by greater number of postoperatives on the right half of the graph than on the left half.

hypoproteinemia whereas 9 showed a postoperative hypoproteinemia. Our most marked cases of hypoproteinemia have occurred in this disease.

Acute appendicitis without peritonitis failed to reveal significant changes in proteins. Of 19 patients who had a toxic coliter removed 13 showed an average decrease of 7.4 per cent only 1 of these showed a hypoproteinemia. Of 20 gynecological patients, 14 revealed a decrease in proteins of 6.3 per cent and only 1 case of hypoproteinemia was encountered. Of 9 burn cases 5 had a hypoproteinemia on admission.

In gastrointestinal fistula (chiefly ileostomies for ulcerative colitis or permanent colostomies) the average loss of 4.3 per cent following surgery is not significant if blood or plasma administration is considered. Thus, of 5 patients with preoperative hypoproteinemia 4 went through surgery with an average improvement of 12 per cent.

In a group of 69 patients from whom sufficient samples were drawn over a 10 day postoperative period to warrant tabulation a correlation of the percentage changes in the plasma protein, hematocrit and hemoglobin was attempted (Fig. 1). Preoperative values were used as controls and the per cent daily change computed therefrom.

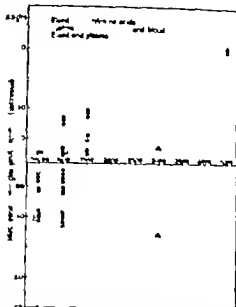


Fig. 3. The effect of the quantity and types of protein-replacement fluids on the plasma protein level. Note that the improvement is proportional to the amounts given and that not until 2,500 cubic centimeters or more as given could consistent improvement be anticipated. Whole blood appeared to produce greater rise in protein levels than did blood plasma; this is attributed to the value of leucocytes as source of protein. The striking improvement here amino acids were combined with whole blood suggests plan of treatment: hereby amino acids would be furnished for those proteins and whole protein (such as blood or plasma) for the circulating proteins.

In peptic ulcer the protein decreased slightly during the first 3 postoperative days, but thereafter improved progressively and remained above the control value. The hematocrit and hemoglobin fluctuated together remaining close to or above the control value for most of the postoperative period. The period of slight decline in proteins is to be correlated with the period of starvation which patients with gastric resection undergo which is approximately 3 days. Further the independent trends of the protein, hematocrit and hemoglobin changes indicate that changes in the former are not due to relative hemoconcentration.

In peritonitis and bowel obstruction the changes are marked and affected hemoglobin and hematocrit values even more than proteins. The protein decrease was greatest between the 4th and 7th days and disappeared

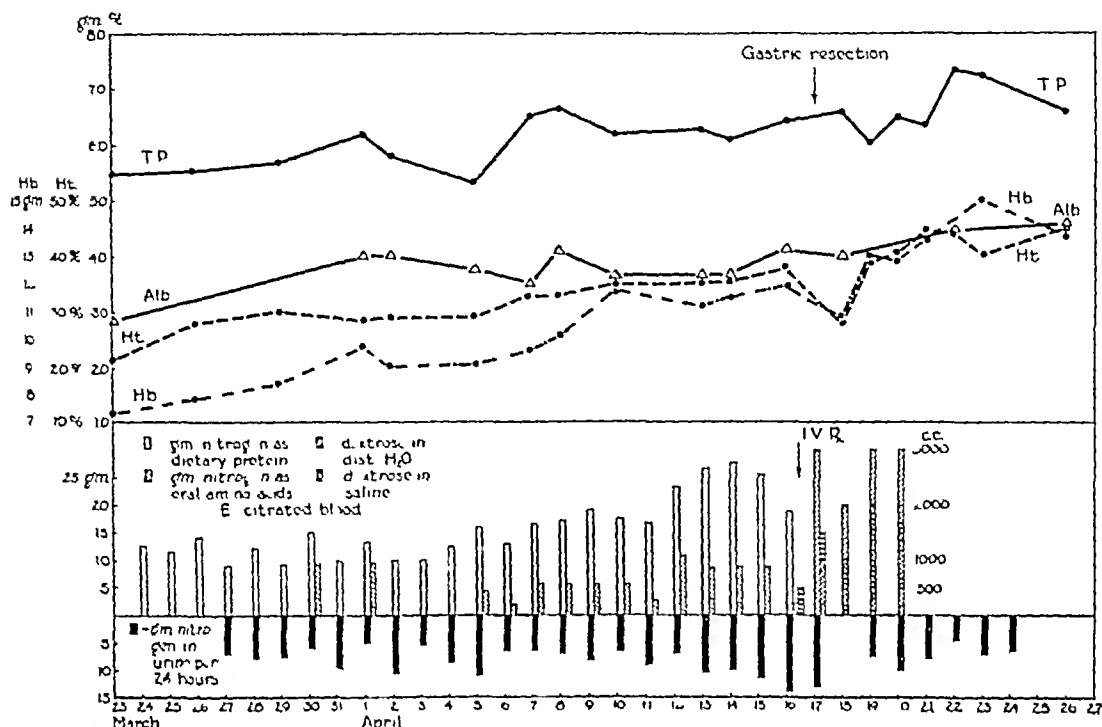


Fig 4 Patient J R, 50 year old white male, with a bleeding duodenal ulcer was admitted with a total plasma protein of 5.58 grams per cent, a hematocrit of 22 per cent, and a hemoglobin of 7.2 grams per cent. Nitrogen balance studies were begun and the effect of a high protein diet alone was observed for several days. This produced some improvement in the hematocrit and hemoglobin but practically none in the plasma proteins. Oral amino acids were then administered in addition to the high protein diet and from then on a consistent improvement in total protein, hematocrit and hemoglobin was seen so that just before surgery his total proteins were 6.43 grams per cent,

his hematocrit, 37.5 grams per cent, and his hemoglobin, 11.9 grams per cent. An improvement in the albumen fraction of the protein was also noted and a positive nitrogen balance was assured for several days before surgery was carried out. The patient received 1,000 cubic centimeters of blood in the course of surgery and made an unusually fine recovery after operation. At the time of his discharge from the hospital his total proteins were 6.63 grams per cent, his hematocrit, 46 per cent, and his hemoglobin 13.8 grams per cent. (TP = Total plasma protein, Ht. = Hematocrit, Hb = Hemoglobin)

before the hematocrit and hemoglobin changes did. These changes seem to indicate the need for cellular elements as well as protein.

In thyroid disease there was a daily progressive decline of slight degree in all 3 factors, hematocrit and hemoglobin showing greater percentage decline than the plasma protein level.

In gynecological cases there was a roughly parallel drop in all factors, greater than anticipated.

In carcinoma of the colon the plasma proteins dropped at once and remained below control values during the entire period of observation. The hematocrit dropped more slowly but to a greater degree, and the hemoglobin most gradual of all.

In gall-bladder disease, the day to day percentage changes oscillated independently, the final result at the end of the 10 day post-operative period was a moderate decrease in all 3 factors.

Figure 2, presents a correlation of the mortality rate with the incidence of preoperative and postoperative hypoproteinemia. Of the 32 (56.2 per cent) fatal cases, 18 either had hypoproteinemia on admission or after surgery. Furthermore, 20 of the patients with preoperative and postoperative hypoproteinemia experienced one or more of the following complications: impaired wound healing, poorly functioning enterostomies, edema, anorexia, restlessness and irritability, and asthenia.

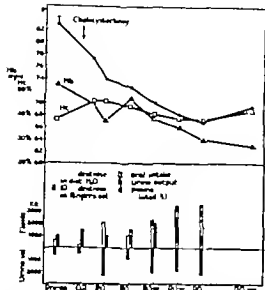


Fig. 5. Patient M. S., 44 year old, white female with acute cholecystitis. Although an apparent marked drop in protein concentration occurs, the initial level is 8.90 grams (probably due to hemoconcentration) and it is always above 6.70 grams per cent. The need for plasma protein in this case was not critical. Note the sharp contrast in the fluid balance before and after surgery.

Figure 3 represents an attempt to evaluate the kinds and quantities of parenteral proteins administered to these patients. Of 24 patients who received 500 cubic centimeters of whole blood or plasma, only 5 showed an increase of plasma protein of less than 0.5 gram per cent. Three who received 750 cubic centimeters of plasma showed a decline in protein levels in the course of treatment. Of 23 patients who received 1,000 cubic centimeters of blood or plasma, or mixtures thereof, 7 showed improvement in protein levels. Of 11 patients who received 1,500 cubic centimeters of blood, or combinations of blood and plasma, 8 showed elevations in protein levels up to 1.2 grams per cent. All who received 2,000 cubic centimeters or more of blood (or combinations of it with plasma) showed improvement in protein levels during the period of observation. Two patients who received 2,000 cubic centimeters of plasma alone showed a protein decrease of more than 1.0 grams. Of 4 patients who received 3,000 cubic centimeters of amino acids intraven-

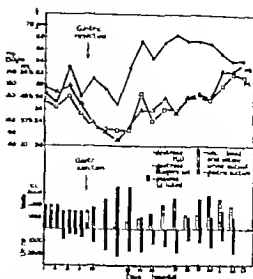


Fig. 6. T. D., 45 year old white male with penetrating duodenal ulcer for which subtotal gastric resection was performed. In the course of treatment he received 1,500 cubic centimeters plasma and 2,500 cubic centimeters whole clotted blood. Although a poor risk, the patient withstood surgery well. At the time of admission the patient's plasma proteins were 5.40 grams per cent, hematocrit was 48 per cent, hemoglobin 13 grams per cent. This improvement occurred despite the fact that the patient was drug addict and an feeding problem. The daily determinations of the hematocrit and hemoglobin determined the use of whole blood postoperatively in this case rather than plasma, and the results would appear to justify this decision. Note that the rise in the hematocrit and hemoglobin does not necessarily produce rise in the total proteins.

ously alone 2 showed a slight improvement in plasma proteins, and 2 a decrease. Four patients who received amino acids and blood totaling in all 5,000 cubic centimeters or more showed the most striking and consistent improvement in protein levels. Figure 4, illustrates the improvement in the hematocrit and hemoglobin as well as the total protein and albumin of such a patient while he had received amino acids and dietary protein alone.

The daily determination of the total protein, hematocrit and hemoglobin afforded information in the selection of the type of parenteral fluid best suited for the patient's needs. For example a patient with normal or slightly elevated proteins and normal or slightly elevated hematocrit and hemoglobin may get along with dextrose and/or saline solutions. Figure 5 illustrates the condition in

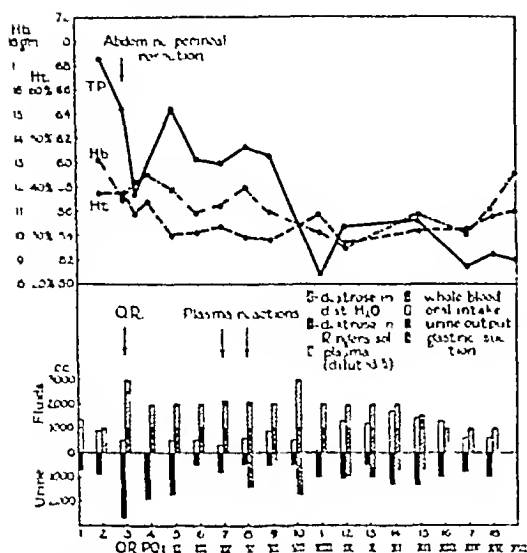


Fig 7 M A, 62 year old female, who developed a marked protein depletion following an abdomino perineal resection for a carcinoma of the rectum. Patient was not given more plasma or blood because of fear of reactions of which she had two (given for an associated ileus). Colostomy did not function for 2 weeks after surgery. Protein depletion followed period of 10 day starvation after surgery. Patient's proteins did not return to the lower limits of normal until 25 days after surgery. Note that the low protein levels persisted while the hematocrit and hemoglobin remained rather stable, her primary need was for plasma protein which was difficult to administer to her.

a patient who was admitted with total plasma protein of 8.30 per cent, hemoglobin of 16.4 grams, and hematocrit of 38 per cent (chronic dehydration). Her plasma protein fell considerably during her postoperative period but was always above 6.70 grams (correction of initial hemoconcentration), her protein reserves were sufficient (attested by normal values throughout her postoperative period) so that need for plasma was not critical. Her fluid balance before surgery is in sharp contrast to the intake and output after surgery was carried out.

Low preoperative total proteins, hematocrit, and hemoglobin are illustrated in a patient with a bleeding duodenal ulcer (Fig 4) and one with a penetrating duodenal ulcer with partial obstruction of the pylorus (Fig 6). In the former patient, a high protein diet and oral amino acids improved plasma protein, albumin, hemoglobin and hematocrit, the patient was given 1,000 cubic centimeters

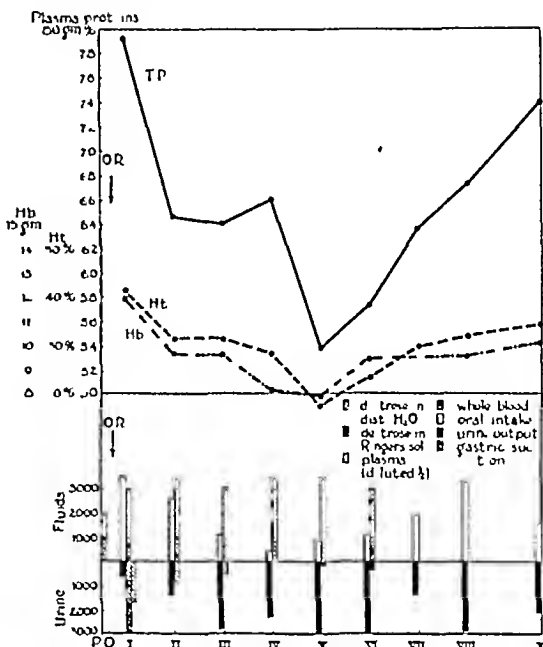


Fig 8 E H, 35 year old white female, with a generalized purulent peritonitis and ileus due to a gangrenous ruptured appendix which was removed. The rapidity with which a protein deficiency can occur, and its improvement as soon as the patient was able to eat is illustrated. Seven hundred and fifty cubic centimeters of plasma was without much effect in preventing this protein loss. More whole blood is indicated by the low hematocrit and hemoglobin values after plasma proteins returned to normal.

of whole blood in the course of a gastric resection and the factors were higher at the time of discharge than before. The positive nitrogen balance attained before surgery is shown. In the latter patient, in whom feeding difficulties were present before and after operation, 2,500 cubic centimeters of whole blood and 1,250 cubic centimeters of plasma were given, protein, hematocrit, and hemoglobin (after the immediate operative losses) increased, which justified the therapy used.

Postoperative decrease in proteins, hematocrit, and hemoglobin is illustrated in a female (Fig 7) whose blood proteins were low from the 9th to the 25th postoperative days, following a one stage combined abdomino-perineal resection for carcinoma of the rectum. She had an ileus during the first postoperative week and the colostomy failed to function for still another week, during this period she virtually starved. Reactions to two plasma

infusions presented further difficulties. The need here was for plasma protein and it was difficult to supply it. The development of marked anemia in addition to hypoproteinemia in a patient with generalized peritonitis and bowel obstruction is shown in Figure 8 although the protein decrease was promptly improved by oral feedings, the anemia was not. Possibly more whole blood could have achieved this improvement as well.

DISCUSSION

In a discussion of the influence of disease upon the blood protein concentration, the term "protein deficiency" is to be preferred to the more commonly used term "hypoproteinemia." First by definition, the latter concerns itself only with the circulating proteins which we now recognize as less important than the tissue protein depots. Second, there is a gradual depletion of proteins due to many causes, which although not necessarily sufficient to bring the circulating proteins within the hypoproteinemia range, are none the less important. Finally a concept of replacement of a protein deficiency in tissues as well as blood will best explain our results with treatment. The importance of tissue proteins has been stressed by Madden and Whipple, Peters, and Elman (25).

At present there is no method for the determination of tissue proteins and one must depend upon indirect evidence such as the fate of protein ingested i.e. that which does not enter the circulation nor is excreted is considered utilized in building up tissue stores. By such evidence Sachar, Horvitz and Elman found the ratio of tissue to circulating proteins of 30 to 1. If this is correct any decrease of plasma proteins implies a depletion of tissue proteins many times greater.

It is desirable to learn the absolute amount of the circulating proteins (1-13). But the dye method for the determination of plasma volume is not a routine method and cannot be repeated at will in the same patient. We attempted however to establish a trend by repeating daily determinations in the same patient. The time required for determining all three factors is less than an hour requires a minimum of personnel and equipment, and

may reveal significant day to day changes. We frequently withdrew blood through the same needle through which intravenous fluid was to be given within an hour the criteria were available to determine the need for blood or plasma.

The upper limit of hypoproteinemia is not established. Binkley and associates considered 6.5 per cent, Kagan 6.0 per cent. In our own experience we found many apparently normal samples around 6.5 per cent, so that we arbitrarily selected 6.0 grams per cent as the limit.

Casten and Bodenheimer considered a fall of 0.5 gram or more in the plasma protein in surgical patients as significant. Such a fall in a patient with an initial level of 5.5 grams per cent is more significant than in one with an initial level of 8.0 grams per cent. A percentage change taking into consideration the control value was reported by us and 10 per cent or more of them merit interpretation.

Often protein changes are attributed to hydermia. Against this is the fact that our samples were drawn several hours after intravenous fluid administration, the only slight hemodiluting effect of intravenous dextrose or saline solution or both and the disproportionate changes in protein and hematocrit so frequently observed. Initial dehydration and hemoconcentration has, however to be considered.

An incidence of hypoproteinemia in surgical patients of 22.3 per cent is important especially when private and ward patients are included. This as well as other evidence (1) does not support the significance of the diet. When the hypoproteinemia which was corrected by preoperative management is counter balanced by the examples due to surgery the postoperative incidence is approximately the same (21.8 per cent).

Protein deficiency in patients with peptic ulcer has been described (9, 18, 22). The improvement of hypoproteinemia due to peptic ulcer (chiefly due to bleeding) encountered by us is chiefly due to rather large amounts of whole blood plasma, and amino acids used in these patients however the rôle of tissue proteins in correcting hemo-

dilution associated with hemorrhage must also be acknowledged

An incidence of hypoproteinemia in patients with gastrointestinal carcinoma of 29.3 per cent exceeds the average of our series, and is in agreement with the literature (3, 21, 23, 26). Protein deficits following surgery in these patients are also more marked. According to Rhoads and his co-workers (3, 4) the protein deficiency in carcinoma of the gastrointestinal tract can be attributed to hepatic dysfunction.

Pleuritis with bowel obstruction showed in total proteins, hematocrit, and hemoglobin, on an average, very marked alterations. Five factors are responsible for these changes: (2) reduced fluid intake, abnormal fluid losses, bowel distention, strangulation, and infection. Evans, in producing bowel obstruction in dogs by strangulation, could account for the actual amount of plasma lost from the circulation with fluid collected from the peritoneum and lumen of the bowel, moreover, this fluid approximated that of plasma in its protein content. Fine and associates could correlate distention of the small bowel with a fall in plasma volume which would improve with decompression.

Casten, Bodenheimer, and Barcham (9) reported a drop of more than 0.5 gram total proteins in the majority of major abdominal laparotomies and other conditions. Although the average decline in acute appendicitis, uncomplicated biliary tract disease, thyrotoxicosis, gynecological disease, and similar conditions is not marked, individual cases (Fig. 5) may show sufficient changes to warrant following total protein, hematocrit, and hemoglobin changes postoperatively. The high mortality and the incidence of nonfatal complications of hypoproteinemia stresses its significance. Moreover, the fact that hypoproteinemic ulcer patients showed improvement indicates the possibilities of appropriate preoperative and postoperative therapy. This is supported by the direct relationship between the quantities of whole blood, plasma, amino acids, and combinations thereof, and the improvement in protein levels.

The ability of whole blood to raise plasma proteins better than plasma or amino acids

alone, agrees with experimental work (24). An adequate caloric intake for a surgical patient would require 26 blood transfusions of 500 cubic centimeters each per day if no protein value is attached to hemoglobin (18). Actually, whole blood or plasma in large amounts corrected the hypoproteinemia in carcinoma of the colon (6).

Amino acids given after operation to several patients with hypoproteinemia did not rise markedly the plasma protein, as reported before (6, 9, 20). Possibly these amino acids were exclusively utilized for restoring the tissue proteins. The marked improvement noted, however, when amino acids in sufficient quantity were combined with whole blood transfusions, suggests better treatment of hypoproteinemia. If amino acids are used for tissue proteins, whole blood or plasma may raise the circulating proteins.

Although several formulas exist for the estimation of the amount of plasma necessary for shock due to burns, or for blood necessary in hemorrhage, nothing aids the surgeon in determining how much blood or plasma the postoperative patient may need. We believe repeated daily observations of plasma protein, hematocrit, and hemoglobin will help in judging the amount and type of fluid to be given.

CONCLUSIONS

1 Plasma protein was determined in 278 surgical patients, the influence of surgery was followed in 193 of these. Hypoproteinemia was encountered most frequently in bleeding peptic ulcers, carcinomas of the gastrointestinal tract, bowel obstruction, and intestinal fistulas.

2 The hypoproteinemia in peptic ulcer patients was corrected by liberal amounts of blood, blood plasma, and amino acids.

3 Hypoproteinemia in carcinoma of the gastrointestinal tract, bowel obstruction, and intestinal fistulas was aggravated by surgery.

4 Hypoproteinemia improved markedly if intensive therapy was employed.

5 Of 32 fatal cases, 18 either showed a hypoproteinemia before or after surgery.

6 Incidence of plasma protein rise was related to the amount of whole blood, plasma, or amino acids, and combinations thereof.

administered. Consistent improvement was seen when 2000 cubic centimeters or more of blood alone or in combination with plasma or amino acid was given.

7 Whole blood appears to improve plasma proteins more than does plasma due to the value of hemoglobin as a protein source.

8 The combination of amino acids and whole blood as a means of treating hypoproteinemia warrants further use.

9 The daily observation of the total protein hematocrit and hemoglobin is suggested as an aid in deciding whether whole blood plasma, or dextrose and/or saline solutions meets the patients requirements best.

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RED CELL TRANSFUSIONS IN THE TREATMENT OF ANEMIA

Further Observations

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DURING the past 6 months there has been a marked increase in the use of red cell suspensions for the treatment of anemia. Although a relatively small number of cases have been published, the American literature is so voluminous that it is difficult to summarize.

In 1913, Robertson¹ gave transfusions of red cells that had been prepared in fairly large volumes of dextrose-saline solution. In 1914, deGruy² described the use of a special method of preparing red cells in the preservation of the cells rather than in the preservation of the plasma. The results for the use of red cells were reported by Castellanos³ in 1917 and by Schwartz⁴ in 1920. Both of these authors called attention to the use of plasma free erythrocyte transfusions in children.

The large scale preparation of plasma in the present war has made available large quantities of red cells. The English have recognized the beneficial effect of transfusions of concentrated red cell suspensions in the treatment of anemia and their use has been described in detail (7, 9, 11).

The advantages of red cell suspensions over whole blood are their economy (the plasma is available for other purposes), the practicability of giving large quantities of cells over a short period of time, and the use of a smaller volume of fluid in patients with cardiac disease. The purpose of the present paper is to record further experiences with red cell transfusions in a series of patients with various types of anemia.

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The red cell suspensions used in this study were obtained through Dr. S. O. Levinson of the Samuel Deutsch Convalescent Serum Center of

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Michael Reese Hospital. Plasma is prepared commercially at this center and the red cells had heretofore been discarded. Five hundred cubic centimeters of blood is drawn from each donor, who has previously had a Kahn test and his blood typed. The blood is drawn into a centrifuge bottle containing 50 cubic centimeters of 4 per cent sodium citrate solution and is centrifuged at 1500 revolutions per minute for 15 minutes. The plasma is then aspirated off and a sample placed in a sterility test. The bottles containing the packed cells are sealed and a pilot tube containing whole blood is attached to the outside for subsequent matching with the prospective recipient. All cell suspensions are stored in the icebox at 1 to 6 degrees C until used. The hematocrit on such suspensions was found to average from 87 to 90 per cent.

For practically all transfusions the red cells from two donors of the same blood group were pooled and given at one time. Either type O cells or cells of the same group as the recipient were used. Before pooling, the cells from each bottle were matched against the recipient's serum. In earlier transfusions, isotonic saline solution equal to the amount of plasma that had been withdrawn was added to the cells. This was done mainly to facilitate the flow through the transfusion needle. It was later found that the addition of so much saline was unnecessary.

The technique used in most of the red cell transfusions was as follows. Six hundred cubic centimeter vacuum bottles (Baxter transfusion sets) were prepared containing 100 cubic centimeters of saline solution. The cells from two compatible donors of the same blood group were drawn into the vacuum bottle through a glass tube and a metal mesh filter, care being taken to leave behind the gel which gathers on the surface. This red cell suspension flowed freely into the recipient through an 18 or 19 gauge needle. The flow can be accelerated by raising the bottle to a higher level than usual. When smaller

Dr. Levinson gave continued co-operation and guidance during this work

needles are used it is well to connect a bottle of saline solution to the cell bottle with a 1/2 tube so that the needle can be washed out with a more dilute suspension if necessary.

In the majority of cases, the packed red cells were given within 3 days from the time they were drawn. In a few cases they were given up to 5 days. No hemolysis occurred in the remaining supernatant plasma during this time. The red cell suspensions were not kept longer as it has been shown that when citrated whole blood is stored for more than 3 days, the survival time of the injected red cells decreases (11). Blum claims that red cell suspensions to which dextrose has been added give satisfactory hematologic and clinical results even when kept up to 3 weeks before injection.

Although most of the cell transfusions were given to patients in the hospital, it also was found practical to give them to ambulatory patients in the out patient department. Four patients in the out patient department at the Presbyterian hospital were given 6 transfusions. The transfusions were given between 8:00 and 9:00 a.m. and if no reaction occurred by 3:00 p.m., they were allowed to return home.

RESULTS

A total of 227 red cell transfusions have been given to 100 patients with various types of anemia. One patient in the series whose case will be discussed later received 46 of these transfusions. The causes and types of the anemia for which the transfusions were given are recorded in the table. About 80 per cent of the cell transfusions consisted of the pooled red cells from two donors each of whom gave 500 cubic centimeters of blood. This unit is referred to as a 500 cubic

centimeter red cell suspension (or transfusion). It actually contains approximately 450 cubic centimeters of packed cells. Patients with mild anemia usually received a single 500 cubic centimeter red cell transfusion while in the severe cases, this amount was given on each of two consecutive days. The transfusions were then repeated as often as desired to obtain a satisfactory red cell count and hemoglobin level.

Red cell counts and hemoglobin determinations were made usually within 4 hours before and from 8 to 24 hours after the transfusions. In 61 patients after a single transfusion of a 500 cubic centimeter red cell suspension, the erythrocyte count increased from an average of 3.56 million to 4.14 million per cubic millimeter and the hemoglobin from 10.0 to 12.5 grams per 100 cubic centimeters. In 15 patients who received two 500 cubic centimeter cell transfusions on successive days, the erythrocyte count increased from 3.40 to 4.05 million per cubic millimeter and the hemoglobin from 6.5 grams to 11.4 grams. The increase in red count and hemoglobin value was therefore just twice as great with 1000 cubic centimeters as with a 500 cubic centimeter red cell transfusion. As might be expected the rise in the blood values in individual cases showed rather wide variations but the increases in general compared favorably with the effects to be expected from equivalent amounts of whole blood.

No actual determinations were made of the period of survival of the transfused red cells in the recipients. As the rate of blood formation and destruction varies greatly in different types of anemia the blood counts taken in the weeks following the transfusions were not definite index of the survival of the injected cells. Follow-up counts in many patients after red cell transfusions showed a similar survival of the cells to what was seen in the same patients after whole blood transfusions.

All patients were observed carefully for the occurrence of reactions during or following red cell transfusions. A patient was considered to have a reaction when there was chill or a temperature elevation of over 5 degrees F. Reactions occurred in 7 of the 100 patients who received multiple cell transfusions for the treatment of leukemia or aplastic anemia. All of these patients had similar reactions previously with whole blood. Of the remaining patients who received 159 cell transfusions, reactions occurred 5 times, a rate of 3 per cent. The average reaction rate of 100 consecutive whole blood transfusions¹

TABLE—CAUSES OR TYPES OF ANEMIA FOR WHICH RED CELL TRANSFUSIONS WERE GIVEN

	No. cases
Acute hemorrhage (including bleeding peptic ulcer)	10
Chronic hemorrhage	
Cardiac (with hemorrhage)	
Post-operative anemia	5
Perilous anemia	
Iron deficiency anemia	3
Sepsis	9
Toxic anemia	5
Nephritis with nitrogen retention	
Leukemia	
Hodgkin's disease	1
Sickle cell anemia	
Aplastic anemia	1
Carcinoma of liver	
Nutritional deficiency	1

¹Patients who received repeated transfusions for the treatment of leukemia were omitted from this count.

given during the same period was 70 per cent. These results are in agreement with others who have found a lower reaction rate with red cell suspensions than with whole blood (7, 9). There were no serious effects of the reactions that occurred after cell transfusions. Jaundice was observed in 2 patients, but this was transitory and no change in kidney function could be demonstrated.

Some of the benefits observed with red cell transfusions are illustrated by the description of specific cases.

A male patient, aged 60 years, with gastrointestinal bleeding and pernicious anemia was admitted to the Henrotin hospital by ambulance for the purpose of receiving red cell transfusions. The erythrocyte count was 1.49 million per cubic millimeter, the hemoglobin 3.8 grams per 100 cubic centimeter and the blood film revealed macrocytosis and hypochromia of the red cells. In the course of 5 days, he received four red cell transfusions of 500 cubic centimeters each of which raised the erythrocyte count to 3.92 millions per cubic millimeter and hemoglobin to 13.0 grams per 100 cubic centimeters. He then was discharged to his physician for further diagnostic study. Rapid correction of a severe anemia is shown in this patient.

Another patient, a male, aged 40 years had refractory bleeding from a duodenal ulcer. During the course of 16 days, he received 9 red cell transfusions of 250 to 500 cubic centimeters each, which was equivalent to 7.4 liters of blood. Bleeding stopped at the end of this time. Operation would probably have been performed in this case if sufficient blood had not been available for repeated transfusions.

A female patient, aged 34 years came to the hospital with a marked iron deficiency associated with achlorhydria and moderate menorrhagia. Her red cell count was 3.03 millions per cubic millimeter and hemoglobin 4.1 grams per 100 cubic centimeters. It was necessary for her to leave for another city in a few days. After the transfusion of 500 cubic centimeters red cells on each of two successive days, the erythrocyte count increased to 5.2 millions per cubic millimeter and the hemoglobin to 11.5 grams per 100 cubic centimeters. The rapid change from a marked pallor to a pink color to the skin and mucous membranes was a striking phenomenon. The red cells she received contained approximately 1000 milligrams metallic iron which becomes available for hemoglobin formation as the cells are destroyed.

Whole blood transfusions are of considerable temporary benefit in some patients with subacute leukemia. Besides the feeling of well-being, there is often a reduction in fever. Red cell transfusions produced such an effect in a woman, aged 36, with subacute myeloid leukemia. On several occasions after cell transfusions, her temperature which had risen to 101 degrees F each day markedly improved. The beneficial effects began to wear off in 5 to 6 days as they did also after whole blood transfusions.

A very practical use for red cell transfusions is for the patient with refractory or aplastic anemia.

Such patients are usually dependent on repeated blood transfusions as long as they live.

One such patient, a male aged 45 years, with an atypical chronic lymphatic leukemia, had an aplasia of erythropoietic tissue and had apparently completely lost the power to form red cells. The case is described in detail in previous communication (1). Over a period of 1 1/2 years he received 46 red cell transfusions, most commonly of 500 cubic centimeters each. The total red cells given were obtained from 34.5 liters of whole blood. It was the custom to give him 500 cubic centimeters of cell suspension on each of 2 consecutive days about once a month. After the transfusions, the red cell count would increase to around 2.5 millions per cubic millimeter, after 4 weeks the count gradually decreased to 1.0 million per cubic millimeter. Assuming that this patient formed none of his own corpuscles, the injected red cells were estimated to survive for an average period of 30 days.

COMMENT

Enough evidence has been presented in the literature to establish red cell transfusions as a satisfactory substitute for whole blood in the treatment of anemia. Many patients who do not receive whole blood at the present time because of the difficulty and expense involved, would be benefited by large red cell transfusions. The anemia which results from acute hemorrhage requires 6 to 8 weeks for spontaneous recovery. With repeated 500 cubic centimeter cell transfusions, recovery of such an anemia is obtained within a few days, thus hastening convalescence greatly. Red cell transfusions would also be beneficial to patients before operation and after operation and to patients with chronic sepsis when the erythrocyte count and hemoglobin values are below the normal level.

For the present study the red cell suspensions were obtained from a center where plasma is prepared for commercial purposes. It is quite practical for such centers in metropolitan areas to make available both plasma and red cell suspensions to the various hospitals in the vicinity. By dividing the expense between the plasma and red cells, the present cost of plasma could be reduced. Also, the cost of the red cell suspensions would be much less than is now paid for whole blood from the professional donor. If red cell suspensions were made generally available at a low cost, many patients with anemia would be treated more adequately than is possible at the present time.

SUMMARY

A total of 227 red cell transfusions have been given to 100 patients with various types of anemia. One patient received 46 cell transfusions over a period of 1 1/2 years. The erythrocyte count and hemoglobin value in these patients increased to about the same extent as with whole blood.

The percentage of reactions was lower than with whole blood transfusions. It is concluded that red cell transfusions are a satisfactory substitute for whole blood in the treatment of anemia and that they involve less difficulty and expense.

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CARCINOMA OF THE CERVIX—THE WERTHEIM OPERATION

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THIS paper represents the personal experience of the author in the radical surgical treatment of cancer of the cervix of the uterus. It is not a plea to others to undertake such surgery. Frank W. Lynch, Victor Bonney, and (the late) Fred J. Taussig have been used as guides as the work has progressed. Their enthusiasm and their well done work were inspirations. Bonney's results, so well known to all of us, were excellent but his mortality, even in his last two series of 100 cases is too great. His mortality figures had to be bettered. This might be accomplished by a better selection of cases and perhaps by the use of improved preoperative and postoperative treatment. Lynch's (2, 3) proof of the presence of apparently viable cancer cells in cervixes removed after radiation and his encouragement to the author while in San Francisco spurred on this surgical experience. Taussig's (5, 6, 7) careful and thorough dissection of the pelvic lymph nodes as an adjunct to radiation of the cervix and pelvic tissues, and the apparent ability to cure, at least for 5 years, some patients with positive lymph nodes led to a desire to see his work. The observation of his dissections while in St. Louis demonstrated that part of the surgical procedure. Taussig advises pelvic lymph node dissections in all group C patients treated by radium. The results in our clinics in 12 Taussig operations caused us to decide to try, not his operation, but a radical surgical removal of the uterus which a combined radical surgical removal of the uterus was attempted, and in addition his method of lymph node dissection was carried out. It has been obvious to the author, after the observation of possibly 2,000 cases of cancer of the cervix, that radiation is not the ideal method of treatment. Radiation reactions are occasionally very severe and the morbidity caused by the treatment in a large group of patients is great and depressing. It is not uncommon to find that in early cases patients fail to respond to treatment when it is obvious that if the patient had been operated upon, success might have followed. The larger the experience with radiation and the longer the follow-up of cases, the more discouraged our staff has become over our results. Pa-

tients with advanced cervical cancer occasionally do exceptionally well, and yet if in such a hospital as the Pondville Hospital (Massachusetts Department of Public Health), the absolute curability figures are considered it is apparent that in only the early and favorable cases are patients cured. Of 1000 patients of all groups and grades coming to that hospital only 100, or 10 per cent have survived 5 years. It should be mentioned here that many of the patients at Pondville had been radiated or operated upon before coming there. In the Massachusetts General Hospital, with the use of a similar form of treatment, the end-results for 395 patients who received treatment (and not including those who were not treated) show a 5 year curability of 15.9 per cent. Yet in a specially studied series of 70 patients at the Pondville Hospital (4) treated by the combined method of x-ray and radium, and including all the patients that were treated, 34.3 per cent survived 5 years. This is very confusing, but it is clear that certain small series of patients treated as a special group and therefore a *selected* group, will do better than a very large group as a whole. It is unfortunate to think that in special series selections of cases are made, but it does seem obvious from the figures given that that, plus the fact that the surgeon and roentgenologist are doing a piece of research work, makes a great deal of difference.

Five reasons have led to the introduction of an old and formidable operation into the treatment of cervical cancer in our clinics. These five reasons follow:

- 1 If the cervix has been removed there is no chance for a recurrence in it.
- 2 If the cervix has been removed no cervical cancer can re-grow in it as a reoccurrence.
- 3 Certain cancers of the cervix are radiation resistant—a fact proved at the Pondville Hospital (8), where multiple biopsies are performed at the time the x-ray and radium treatment are being carried out.
- 4 There will be less damage to the bowel if surgery is undertaken. Lately 46 cases of serious bowel injury have been found in our clinics.
- 5 From the work of both Bonney and Taussig it is obvious that patients with lymph node metastases can be cured by surgery in some instances and the author believes that it is not possible to

From the Pondville Hospital and the Vincent Memorial Hospital (the Gynecological Service of the Massachusetts General Hospital)

TABLE 1—NUMBER OF OPERATIONS—
FEBRUARY 1939 TO JULY 1943

	Number	Deaths	Percent
Total	53	9	
Elective	47		
Nonelective	6	6.6	

cure with radiation cancer in lymph nodes deep in the pelvis.

Other reasons, such as bleeding, discharge, fistulas, radiation reactions, etc. could be cited against radiation but the five reasons here given are the real ones upon which this surgical work was predicated.

In answer to this the proponents of radiation will remark the seriousness of the surgical procedure and will call attention to the danger to the ureters and bladder. This matter will be discussed later and it is of real consequence in a group of surgical patients.

The surgery must be limited to certain types of patients, ideally they should be thin young, in good health and have an early growth. One would think that patients with such qualifications would be impossible to find but the number operated upon in our series is increasing each year and we have only occasionally stepped outside the bounds of the qualifications here enumerated.

One other group has been operated upon and will be discussed separately in the statistics and results. These are the patients in whom one or two radiation attempts at cure have failed. These cases are nonelective and are must cases and the results would be expected to be poor and they are. Yet one of our patients in this group has lived for 2 years and 1 month.

MATERIAL (TABLE 1)

The elective material consists of a total of 47 cases—27 from the Pondville Hospital (Massachusetts Department of Public Health) 14 from the Massachusetts General Hospital, and 6 from the author's private practice. In the nonelective group there were 6 cases—4 from the Pondville Hospital, and 2 from the Massachusetts General Hospital. This surgical series was begun in 1939 and has continued to date. In the first year there were 2 patients operated upon in 1939, 8 in 1940, 8 in 1941, 19 and in 1942 (to July) 10. More patients to operate upon were found than expected.

CLASSIFICATION OF MATERIAL

The material was classified into elective and nonelective cases and the two groups are considered separately. In the elective group according

to the American College of Surgeons classification, for in such a small group the League of Nations classification is too complicated, there were 34 Class A cases, 9 Class B cases, and 4 Class C cases. The types and grades of malignancy were as follows—adenocarcinoma, 6 adenocarcinoma, 1 epidermoid cancer grade I 4 epidermoid cancer, grade II 13 epidermoid cancer grade III, 10 and epidermoid cancer grade IV 1. Cancer which could not be graded was found in 2 cases. The ages of the patients showed that 5 were from 20 to 29, 11 from 30 to 39, 21 from 40 to 49, 9 from 50 to 59, and 1 was 65 years old. Most of the tumors were therefore early most were rapidly growing cancers, and most were in patients who were less than 50 years of age. Complete statistical work on such a small series is of very little value and is not presented.

PREPARATION AND CARE OF THE PATIENT

The preparation of the patient for operation is very important. This consists of admitting the patient to the hospital 4 to 5 days before the operation is to be done. The blood chemistry must be brought to normal, vitamins are supplied in large amounts to arrive as far as possible at a normal level, and blood transfusions are commonly given. Two days before operation the patient is started on 1 gram of sulfadiazine every 4 hours. The blood level has been determined in the beginning and is usually found at 6 to 8 milligrams per cent. Lately the sulfadiazine has been given without determination of the level. At operation 4 grams of sulfanilamide are placed in the large pelvic defect under the new peritoneal floor. Sulfadiazine is continued by mouth as soon as the patient can take it and is continued for 7 days after operation. In the first years sulfanilamide was used and sulfapyridine followed that, but for 2 years sulfadiazine has been the chemical of choice. Knowing full well the possibilities of foreign body reactions caused by these drugs in the peritoneal cavity sulfanilamide has been very carefully placed under the new peritoneal floor.

In some cases of the elective group x-ray and radium treatment were given before operation. Rarely and yet very definitely occasionally has radiation seemed to make the operation any more difficult. 40 per cent of the patients had radiation treatment before operation. Some had radium alone some but one-half the regular dosage of x-ray or radium or both, and 10 patients had the complete x-ray and radium cycle before operation. As experience is greater it is felt that either no radiation at all or one-half the usual x-ray radiation with no radium is the method of choice.

MEIGS CARCINOMA OF THE CERVIX

TABLE II — COMPLICATIONS

	Cases	Percent
Ureterovaginal fistulas	5	10.6
Ureteral catheterization at operation	17	36
Ureterovaginal fistulas after catheters	2	11.7
Ureterovaginal fistulas without catheters	3	10

in preparation. A small amount of radiation to injure the tumor cells, and a very small amount will do so, is probably worth while. No figures are available to settle the question definitely.

THE OPERATION

The operation is commenced by preparing the vagina by cleansing with dry gauze and washing out the vagina carefully with a double strength Schiller's solution. The bladder is catheterized and a self-retaining catheter left in place because as the operation takes a considerable time it is well to have the bladder remain empty all the time. It was formerly thought necessary to catheterize the ureters but as ureteral fistulas were considered as possibly due to this maneuver it was abandoned. The catheter is stiff and the bared ureter is easily caught by gauze sponges and stretched. Also it was felt that when the ureter was gently picked up with forceps perhaps the catheter as well as on the outside of the ureter might have something to do with ureteral injury. Of the entire group, however, just as many fistulas have occurred in patients having no ureteral catheters used as in those with them, so no real advice can be given about this problem.

The incision is made from the symphysis to well above the umbilicus, for the dissection starts along the common iliac artery and the aortic bifurcation is usually above the umbilicus. The first step is to dissect the bladder peritoneum from the front of the uterus and to release the bladder as far down the vagina as possible, usually to the trigone. The infundibular pelvic ligaments are ligated, the catgut is left long, and a clamp is applied and brought over the edge of the wound. The round ligament is released and the catgut tie is clamped and also brought over the edge of the wound. The dissection is then carried down the common iliac artery on the right side to its bifurcation where a lymph node may be found. The external iliac vein is located and it and its artery are stripped of all fat and possible nodes. The muscular area lateral to the artery is cleaned off, thus exposing the iliohypogastric nerve. At the bifurcation of the internal and external iliac arteries the ureter is seen attached to the medial peritoneum, it is dissected free of the peritoneum down to the area where the uterine

TABLE III — RESULTS

Recurrent disease (nonelective)	6
Living (2 years and 1 month)	1
Elective cases	47
Living	44
3-4 years	5
2-3 years	4
1-2 years	13
Under 1 year	22
Dead	3
2 years and 2 months	1
1 year	2

artery coming off the internal iliac artery crosses it. This deep angle of internal iliac artery, ureters, and uterine artery and vein is a difficult place to dissect, but it must be done carefully and completely because of the possibility of a ureteral node being present. The uterine artery is tied as it arises from the internal iliac and is pulled toward the uterus, thus exposing the ureter which passes under it and on into a definite groove or canal through which it goes on to the bladder. The release of the operation for occasionally it is extremely adherent. It must be freed entirely or enough vagina cannot be removed, and yet to dissect it free means to use force and a certain amount of injury occurs, it is here that the author believes the ureter is injured and fistulas develop. The ureter is freed from this canal down to the entrance into the bladder, this area is not difficult to locate as the ureter flares out as it reaches the bladder. Next the obturator fossa (first demonstrated to the author by Dr. Taussig) must be cleaned out. It lies below the distal part of the external iliac vein and is easy to find. There is usually a large amount of fat in the fossa and it is an excellent place for lymph nodes to lurk. In 5 of our 8 cases with positive lymph nodes the obturator nodes were positive. The obturator nerve is easily found running like a banjo string across the fossa. In the depth of this fossa lie arteries and veins that branch from the internal iliac distal part of the external iliac artery is cleaned of fat and nodes. In our series, however, this area has not contained a positive node. It is often difficult to release the bladder at its lateral extensions from the cervix, and care and patience must be exercised here. There are apt to be blood vessels that are confusing and that bleed easily. The next step is the dissection of the left group of blood vessels and lymphatics, and the ureter and obturator fossa. When all of these are released and the uterus is free the dissection is carried down the sides of the rectosigmoid, releasing the peritoneum of the cul-de-sac of Douglas in its en-

tivity The cleavage plane between the vagina and rectum is found and the rectum is dissected as far down the vagina as possible. This part of the operation is occasionally difficult and must be carried out thoroughly for it is best to remove as much as possible of the cul-de-sac. When this is done the vagina is cut across and below the growth and as much as possible is removed. Occlusion clamps across the vagina are not used. It is often noticed that even though the operator thinks he has removed a large cuff of vagina, when the specimen is opened he is chagrined to see how little he has removed. With the uterus out and the vagina open the vagina may be sutured with a circular running stitch, not closing the vagina but around its cuff as a hemostatic stitch. At the end of the operation the blood vessels, ureters, and obturator nerves are widely exposed. The ureters look like loose telegraph wires running across the pelvis. Care is taken to see that all bleeding has ceased. Then without attempting to drain the pelvis (the vagina is open) and without supporting the vagina by any ligament, peritonealization is carried out by suturing the peritoneum of the posterior pelvic wall to the peritoneum of the raised bladder flap. Four grams of sulfanilamide are placed under the peritoneal flap and the peritoneum is closed tight. The abdominal wall is then closed in layers. It is usual during the operation to have the patient transfused as at the end of the operation a certain amount of shock can be expected. Constant bladder drainage is continued and the patient is put to bed with the foot of the bed on low shock blocks. From then on, except for sulfadiazine by mouth, the usual postoperative care is given. The patient is allowed to be out of bed on the 14th day.

RESULTS

Of 47 selected cases in which patients were treated in the fashion described none has died, an operative mortality of 0 per cent. It was essential in this series that the mortality be low for the results with radium in the radiated cases are so good that 10 to 20 per cent mortality would prohibit surgery. A mortality of 0 per cent, or a very low mortality gives the operator feeling that at least he is as well off as is the radiologist in treating this type of disease.

The most significant complications are difficulties with the urinary tract (Table II). Cystitis, dilated ureters, and hydronephroses are the rule after operation, not the exception. In most cases an intravenous pyelogram taken before discharge will show large ureters and kidney pelvis, but this condition will clear up. Occasionally patients

have difficulty in voiding or emptying the bladder due to injury to the sympathetic or parasympathetic nerves. In 5, or 0.6 per cent of the 47 cases, ureteral fistulas developed, which in 41 cases will mean ultimate nephrectomy. This is a serious complication but not a fatal one. In 1 patient with a huge tumor both ureters were injured. Of the cases with ureteral fistulas a nearly equal percentage had had a ureteral catheter placed at operation as had not. Three of the 5 patients with fistulas had had previous x-ray treatment and 1 had had a cesarean section of the low transverse cervical type 4 months before operation. This type of cesarean section should never be done if a Wertheim operation is contemplated afterward. There have been no vesicovaginal fistulas. The bladder was opened once and it was closed without any ill effect.

In 8, or 17 per cent of cases, lymph nodes were found to be positive. Iliac nodes in 4, ureteral nodes in 1 and obturator nodes in 5. The examination of the removed nodes was not carried out by serial section as was done in Dr Tansig's, and therefore it is quite possible that certain positive areas were overlooked in other nodes. It is extremely important, however, to realize that 8 of these patients with very early lesions would have eventually died if radiation had been used. In this group with positive nodes only 1 patient has succumbed so far. It is too early to tell what the 5 year results will be in these cases with positive nodes but they certainly will be better than in similar radiated series.

Of the 6 patients with recurrent disease or non-elective cases in whom operation was forced upon the surgeon 5 have died and 1 died of general peritonitis after operation. This is the only death in the series and, adding the groups together makes death in 53 patients, or 1.9 per cent. It is interesting to note and of real importance that the patient who died was the only one of the entire series who was not prepared with a sulfonamide. General peritonitis used to be the most common cause of death from the surgery of cervical cancer but only 1 of this series of 53 cases succumbed to this infection. Of the 6 cases with recurrent disease 1 patient is still alive without disease at 2 years and 1 month and each of the others lived over a year.

Enough time has not elapsed to make the end results (Table III) of any value but 5 are alive over 3 years, 4, over 2 years, 13 over 1 year and the others, for varying months under 1 year. Of the elective cases 3 died of cancer. One died of cancer of the lung 3 years and 3 months after operation and 1 died of generalized metastases.

throughout the body. This patient had huge pelvic nodes at operation and all were dissected out as carefully as possible. The third patient had a huge tumor and surgery should not have been undertaken. Three patients have recurrent disease and in one of these it has been possible to obtain a positive biopsy from the vagina. It is impossible to judge the value of pre-operative x-ray treatment for the patients have not been operated upon long enough to offer any possible basis of comparison. It is the author's feeling that it does not matter whether it is used or not, but another 5 years will be necessary to prove this.

If it were not for injury of the ureter it would probably be safe to say that this operation is better than radiation, but a ureteral injury of 10 per cent in early cervical cancer is too large. Efforts are being made to lower this percentage. The fact that lymph nodes can be removed and that Bonney and Tausig have demonstrated that 20 per cent with positive nodes survive for 5 years gives surgery a distinct advantage over radiation. All such patients in a radiated series must die of disease. They have a one out of five chance after surgery.

It is probable that with required skill strong, young thin patients with more advanced disease should be given the opportunity of surgery rather than chance being placed entirely on radiation. If the nodes of these patients are involved in greater proportion better results will be obtained than with radiation if the mortality can be kept low.

OBSERVATIONS

It is the belief of the author, though not confirmed one, that surgery in selected cases is a better way to treat cervical cancer than is radiation. The experience of the patients who have had both methods of treatment has always been that the surgery was much easier to tolerate than the radiation. Therefore we should not say to patients that radiation is simple we all know better. We know how miserable the patients are after x-ray and radium. Some are sick for weeks some for months and some for years. Surgery is over rapidly and quickly and is certainly more comfortable for the patient than the combined radiation treatment.

CONCLUSIONS

1. The main reason for this paper is to demonstrate that in properly selected and properly prepared patients the Wertheim operation plus the Tausig method of dissecting the pelvic lymph nodes can be accomplished with a low mortality.
2. The number of patients with positive lymph nodes in this selected group of cases is high—17 per cent.
3. Ureteral injury is the greatest drawback to this operative procedure and its incidence must be lowered.
4. It is the belief of the author that this method of treatment of cervical cancer will give better end-results than the present methods of radiation.

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It is obvious to all of us that just as we think our patients are cured certain ones develop a recurrence after 5 years. Often the cancer comes back as recurrence in the cervix. This is eliminated by surgery for there is no cervix present. Surgery of this extensive type can be done safely if we take advantage of all the precautions of modern surgery. The preparation of the patient, the maintenance of good diet, hygiene, the correction of blood chemistry, the use of transfusion, and especially the use of sulfonamides make for safer surgery. This series demonstrates that in the hands of one surgeon nearly 50 selected patients were put through a grueling operative procedure without mortality. Such results will not continue, but if the mortality can be kept low surely this method is a good one.

WAR INJURIES IN CIVIL PRACTICE

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THOSE who have spent years on the surgical wards of civilian hospitals in the South feel that the transition from civilian to military life is not as abrupt and the change in the nature of the work is not as great as it is for the surgeons who have practiced in the East or the North. This is borne out by an analysis of the admissions to the surgical service of the Medical College of Virginia Hospitals in Richmond, Virginia. Where, other than in the South, would a hospital be found in which 0.1 per cent of all surgical admissions were found to have a stab wound of the heart, or 1 in every 1,390 admissions to the hospital had gas gangrene or developed it during the hospital stay?

A brief review of some of these experiences when viewed in the light of current medical articles from the war zone may give a more worthwhile picture of war injuries than a mere recital of material gathered from medical journals to which all have access. Three types of war injuries occurring in a civilian hospital will be discussed.

HEART WOUNDS

Thirteen years ago Dr. L. A. Bigger became professor of surgery at the Medical College of Virginia, and the first case of stab wound of the heart was recognized and operated upon by him. Since then 43 additional patients with stab or bullet wounds of this organ have been admitted. No doubt patients with wounds of the heart were admitted prior to this date, but they either passed unrecognized or a diagnosis had been made too late to permit successful operation. This type of injury is now so thoroughly understood by the house staff that the ambulance surgeon telephones the hospital that he is bringing in a heart case so that an immediate operation can be done if necessary. All but 4 of the patients in this

series were operated upon by Dr. Bigger to whom I am indebted for much of the following data on heart wounds (3, 3).

In arriving at a diagnosis the physical findings in this condition are of greater value than the history. A possible exception to this is the observation of Elkin (6) that the interval of time that elapses between injury and collapse may be of value in diagnosis. Approximately 150 cubic centimeters of blood may enter the pericardial sac before signs of tamponade appear. Once the cavity is filled, a further small increase in the amount of contained blood causes the pressure to rise rapidly with resulting obstruction to the venous return and circulatory collapse. The time elapsing between injury and collapse will therefore give a rough index as to the degree of hemorrhage. The value of this observation is, of course, lessened by several variable factors, for example the heart cavity involved whether auricle or ventricle, and the possible escape of blood through a rent in the pericardium.

The circulatory collapse is always greater than can be explained by the obvious blood loss. The superficial veins, especially the external jugular veins, are always distended in tamponade. The head should be level with, or slightly above the level of the heart when testing for tamponade. The pericardial dullness is not increased immediately after injury. The heart sounds are distant and muffled. The heart may be displaced to the right by hemorrhage into the left pleural cavity.

Respiratory distress and cyanosis are present in advanced tamponade as the result of circulatory collapse and venous stasis. If the blood pressure can be obtained, the pulse pressure is low. The pulse is relatively slow in view of the low blood pressure. Bigger (3) first pointed out the value of fluoroscopy in the diagnosis of cardiac tamponade. The pericardial shadow may be little, if at all, increased, but the outline is immobile. This sign appears to be pathognomonic of tamponade. It also may aid in determining the value

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of conservative treatment Aspiration of the pericardial sac may be resorted to as a diagnostic measure, but this has not been necessary in this series

The patient with a heart wound who does not develop tamponade as the result of free hemorrhage into the pleural cavity or externally, is a more difficult diagnostic problem This was true in the first heart wound operated upon by the author (10) The behavior of the patient and the location of the wound suggested a divided internal mammary artery The incision was made with this thought in mind and considerable difficulty was had in closing a rent in the right ventricle through a relatively small incision over the course of the left internal mammary artery

There are certain signs which may be of diagnostic aid in the absence of tamponade Massive arterial hemorrhage from the external wound should suggest the origin of the bleeding A splashing, churning sound synchronous with the heart beat is significant Air, if present in the pericardial sac, should be recognized by fluoroscopy

Local anesthesia lends itself well to the repair of heart wounds Some of these patients are already comatose from acute alcoholism or cerebral anemia, and all have varying degrees of respiratory embarrassment A practical difficulty sometimes arises when local anesthesia is used When the tamponade is released, they frequently become maniacal, requiring restraint This is an awkward happening at an inopportune time and necessitates the administration of a general anesthesia Because of this, some surgeons use general anesthesia routinely I have used only local anesthesia with the exception of a cardiac exploration which was done in conjunction with an intra-abdominal gunshot wound Spinal anesthesia was given for the laparotomy, and it was found that this permitted examination of the heart through a thoracic incision Spinal anesthesia, however, should not be used for this operation

A left or right parasternal approach should be made depending upon the part of the heart which appears to have been injured At least two, and sometimes three, costal cartilages should be removed Additional space may be

obtained by rongeur away adjacent sternum, or by dividing an additional cartilage and retracting the corresponding rib upward or downward

An extrapleural approach should be made if possible This is more time consuming and frequently is impossible if a right sternal exposure is necessary Regardless as to the approach, a good exposure is essential before the pericardial sac is opened Once the pericardium is opened, one's dispositions must be made rapidly for bleeding becomes excessive when the tamponade is released The incision should be adequate to permit immediate inspection of the involved surface of the heart An apical traction suture of Beck aids in the control of hemorrhage and manipulation of the heart The traction suture can be steadied by the left hand while the left index finger is placed over the opening in the heart Interrupted sutures can be taken in the myocardium beneath the finger as recommended by Elkin (7) Silk is the best suture material Care should be taken to avoid incorporating branches of the coronary artery in the suture If necessary, on-end mattress sutures should be placed in order to avoid this complication The sutures should be tied only snug enough to check bleeding The pericardium is closed loosely with interrupted catgut sutures The lung, if collapsed, should be re-expanded and the chest wall closed without drainage after 5 to 8 grams of sulfanilamide powder have been placed in the pleural cavity Care should be taken that excessive amounts of sulfanilamide are not placed in the pleural cavity for it is rapidly absorbed and may lead to toxic symptoms

All of the heart wounds treated during the first few years of this series were operated upon if they showed any evidence of tamponade or of hemorrhage into the pleural cavity It is now the feeling that in a considerable number of these cases control can be accomplished by simple aspiration of the pericardial sac

The present routine at the Medical College of Virginia Hospitals is as follows A patient suspected of having a heart wound is placed in moderate Trendelenburg position and given morphine and atropine If he is in collapse,

5 minims of adrenalin are given and venoclysis is administered slowly. A small amount of adrenalin may be added to the intravenous solution. The blood pressure is determined frequently, and the veins of the neck are inspected with the patient in the horizontal position. The heart and the lungs are examined repeatedly for significant changes. If definite tamponade or massive hemorrhage into the chest is present the patient is operated upon immediately. If the diagnosis is uncertain and the patient's general condition is not alarming, further determinations of the arterial and venous pressure are made and the outline of the pericardium is followed fluoroscopically. If the tamponade is not excessive the sac is aspirated. This frequently relieves the symptoms dramatically. If temporary relief follows aspiration, the procedure may be repeated depending upon the general condition of the patient and the duration of the favorable response. This temporizing method should be carried out only when the patient is in relatively good condition and with all facilities at hand for immediate operation should the patient's condition deteriorate. Aspiration of the sac has been used several times by Bigger (4) as an emergency measure to lessen tamponade while the operating room was being prepared.

The use of heparin and plasma during the past few years has been of value. Heparin has been given after extensive wounds to prevent clotting within the involved chamber of the heart and plasma has largely supplanted the other intravenous fluids during the actual operation.

The outcome following stab wounds of the heart is more favorable than following bullet wounds. The victim of a bullet wound frequently dies before aid is available, and the operative repair is more difficult. The edges of the wound are cleaner and as a rule there is no loss of tissue in stab wounds. Bullets usually pass completely through the heart and the pericardial sac with the result that there are considerable loss of tissue and a greater possibility of hemorrhage.

Thirty-seven of the 44 cases admitted to the Medical College of Virginia Hospitals were treated surgically. Twenty nine were oper-

ated upon and 20 recovered. Eight patients with milder symptoms were successfully treated by aspiration alone.

ABDOMINAL WOUNDS

In this discussion I had hoped to analyze 70 cases of abdominal wounds treated in the Medical college of Virginia during the past 4 years. Difficulties of time and space proved prohibitive but I have several definite impressions as a result of having followed these patients. The first is that the most important thing is to repair the damage as soon as the condition of the patient permits. This may sound trite but there may be a tendency to forget that the time element in abdominal wounds is paramount. The many recent worth-while advances in the study and treatment of shock may sometimes momentarily divert the attention of the younger men especially from the treatment of the original condition. The hanging drop method is of the greatest importance in determining the degree and progress of shock but valuable time may be lost before operation if too much time is devoted to quantitative determination of something that is clinically measurable. It is safer to reserve this and similar tests for post operative guidance in the average case. This statement may be questioned but with the ready availability of plasma and blood banks, I do not think unnecessary time should be devoted to preoperative study. The time required to examine and prepare the patient, plus that devoted to the routine emergency tests, should also be utilized to give plasma and determine the type of blood needed. By the time these preliminaries are completed, the majority of patients with gunshot wounds will be in the best condition that can be obtained preoperatively and this should be reflected in their blood pressure and general appearance. The actual transfer to the operating room will afford a further therapeutic test of their condition and if their pressure has remained stable the plasma should be continued and the operation begun. The occasional civilian casualty who reverts to shock after the trauma incident to this handling, is sorely wounded and should be set aside pending further study and therapy.

The choice of the anesthetic is a debatable one. Despite the objections raised by many, I feel that a carefully given spinal anesthesia has a wider field of usefulness in abdominal wounds than is generally conceded. It has the obvious disadvantage of lowering the blood pressure, but the proper dose, level, and dilution will minimize this change, and intravenous fluids will further buffer the fall. Spinal anesthesia also has the theoretical and possibly practical danger of causing greater soiling of the peritoneal cavity, but, in carefully chosen cases, I think the operative rapidity, thoroughness, and gentleness which it permits more than offsets the hazards associated with its use. If spinal cannot be used, cyclopropane, intravenous sodium pentothal, or either or a combination of these will be necessary.

Our experience with gunshot and stab wounds of the abdomen has not been unique. Wounds of the upper abdomen are more hazardous than those of the lower quadrant. Combined thoracic and abdominal injuries are especially dangerous. Perforations of the colon have always carried a higher mortality than those of the small bowel. Evisceration does not necessarily spell disaster. The degree of immediate shock that follows a wound of the abdomen is an index of vascular rather than bowel injury. The wound of entrance and the wound of exit gives uncertain evidence, at best, as to the probable damage within. The bizarre behavior of the bullet within the abdomen is proverbial. The only rule to observe is to place a vertical incision over the area of anticipated maximum injury and to continue the search until all of the damage has been repaired. The perforations sutured should total an even number. The usual explanation for an uneven total—that one perforation represents a glancing injury—should be viewed with misgiving. If a missile penetrates the wall of the bowel it usually traverses a portion of the lumen. The most difficult perforation to find is one located along the mesenteric border. The opening is usually obscured by a hematoma between the leaves of the mesentery. These wounds require careful search and more careful closure.

Wounds of the gall bladder are best handled by cholecystectomy if the perforations are

widely separated, or by conversion of two adjacent openings into one defect through which a tube may be sutured. Rents in the liver as a rule respond better to suture than packing. A strip of muscle is also useful as a hemostatic agent. Thrombin is said to aid in checking hemorrhage from the liver. Shattering injuries of the kidney and spleen require removal of the organ. Patients with perforations of the bladder into the free peritoneal cavity may have remarkably few symptoms if the urine is sterile and not too acid.

The question of retained foreign bodies has never given us much concern. If a bullet can be palpated near the surface, we remove it before the patient leaves the hospital to avoid pain and possible subsequent abscess. If it is deeply situated and not adjacent to large vessels or nerves, we disregard it, for we feel that in all probability it will not give trouble. If infection develops the abscess serves as a guide to the retained body and its removal is simplified.

By far the most difficult problem that arises in abdominal wounds is the frequent question as to whether an intra-abdominal injury is present. Probing a tract is dangerous and misleading. Free air beneath the diaphragm is diagnostic of a gastrointestinal perforation if present, but may be deceptive if absent. Peritoneoscopy has a definite field in this type of case and much may be learned from repeated determinations of the specific gravity by the hanging drop method. Muscle spasm and rebound tenderness are probably the two most significant clinical signs. Intra-abdominal hemorrhage and perforations of the bowel cannot be differentiated with certainty, and the distinction is academic, for a reasonable likelihood of either condition demands an exploratory laparotomy.

GAS GANGRENE

A study has been made of all cases of patients with gas gangrene treated at the Medical College of Virginia Hospitals during the last decade (11). Seventy-one patients with gas gangrene were treated during this period and 21 died, a mortality of 30.9 per cent. The number of cases has been constant—36 during the first 5 years, and 35 during the last 5 years.

The mortality however has increased only 8 patients died during the first 5 years, whereas 14 died during the second corresponding period. This was an increase of 75 per cent despite the employment of additional therapeutic measures during this latter period.

The treatment during this decade corresponded to that followed generally with the exception that prophylactic perfringens antitoxin was probably given more freely here than elsewhere and sulfanilamide was used locally very early at the Medical College of Virginia Hospital.

In 1931 9 patients with gas gangrene of the extremities were treated, chiefly by amputation and without perfringens antitoxin only 1 patient died, a mortality of 11 per cent.

During the next 4 years, a prophylactic dose of perfringens antitoxin was usually administered to the traumatic cases and large doses of antitoxin were given therapeutically. Débridements were performed more frequently than amputations. Twenty-seven patients were treated and 7 died a mortality of 26 per cent. In fairness to this method it should be stated that 4 of these deaths followed gas gangrene originating in the trunk. If only the cases were included in which the gas gangrene originated in an extremity the mortality would be exactly the same as in the first year of the tabulation namely 11 per cent.

During the past 5 years larger prophylactic and therapeutic doses of perfringens antitoxin have been given. Roentgen therapy was utilized frequently both prophylactically and therapeutically and during the past 5 years many of these patients received sulfanilamide locally and generally in addition to the usual surgical measures of débridement and amputation. Despite the intensity of this treatment, the mortality has been distressingly high—35 patients were treated with 14 deaths, a mortality of 40 per cent. Four of the 5 patients with involvement of the trunk died. Even if we omit these cases from our tabulation the mortality from gas gangrene of the extremities was 33.3 per cent or three times that of the corresponding infections during the first 5 year period. A careful search was made in an effort to explain this high mortality. Some of these patients had associated injuries or

disease that virtually precluded their recovery but this was also true in our earlier cases. A possible explanation in part, is found in the age distribution in the two 5 year series. Only 2 patients were over age 60 in the first series, while 7 patients over age 60 were found in the second period. The mortality for all patients past age 60 was 77.7 per cent. A second and more disturbing explanation may be that the introduction of chemotherapy in some instances may have beguiled the surgeon into a false sense of security and he may have relaxed unconsciously in his effort to perform a thorough débridement of recent wounds.

A study has been made of the various preventive and curative measures used in the treatment of gas gangrene at the Medical College of Virginia.

Thirty-seven patients who subsequently developed gas gangrene received perfringens antitoxin prophylactically 30 died a mortality of 81 per cent. Thirty-four patients who had not received perfringens antitoxin prophylactically developed gas gangrene and 12 died a mortality of 35.5 per cent. Superficially this would appear to indicate that gas gangrene ran a milder course and was more amenable to treatment if antitoxin was given prior to the clinical onset of the infection. Two facts argue against this interpretation. The patient who did not receive perfringens antitoxin as a prophylactic measure was usually either admitted after the onset of gas gangrene or the possibility of gas gangrene was not considered until the infection was evident, and sometimes advanced. The patient who developed unsuspected gas gangrene as a rule, had a serious associated condition such as diabetes, a pre-existing gangrene, or a perforation of the gastrointestinal tract.

A second method of evaluating the value of perfringens antitoxin may be found in the various numbers of units given in this series. Nineteen patients were given a prophylactic dose of perfringens antitoxin. The mortality in these cases was 26.3 per cent. On the theory that if a small prophylactic dose was beneficial, a larger dose should be more helpful, our routine was then changed and a therapeutic dose of 0.000 units, or more, was given as a prophylactic measure to 7 patients. Five

patients also died in this series, a mortality of 29.4 per cent. In other words, the mortality was slightly higher after a larger prophylactic dose than after a small one. Two patients received 30,000 units, or 15 times the recommended prophylactic dose, and both developed gas gangrene, with death in 1 case.

Unfortunately, data are not available concerning the total number of patients who received perfringens antitoxin prophylactically in terms of the number who later developed gas gangrene, but the above figures cause doubt as to the value of antitoxin as a preventive measure. Pursuing this thought further, it is difficult to see how a massive infection can be cured by antitoxin given therapeutically if a prophylactic injection of antitoxin could not prevent the infection at its inception.

Fifty-seven patients received an average of 31,500 units of perfringens antitoxin therapeutically, and 17 died, a mortality of 30.9 per cent.

Twelve patients received sulfanilamide locally as a precautionary measure, or orally as a therapeutic procedure, and 4 died, or 33.3 per cent.

Eighteen patients received roentgen therapy as a prophylactic and therapeutic measure, or both, and 6 died, again, a mortality of 33.3 per cent. Encouraging, however, is the fact that 35 patients were given roentgen therapy prophylactically who failed to develop gas gangrene.

The operative therapy fell naturally into two groups, namely amputation of involved extremities, or débridement, with excision of infected muscle bundles. Thirty-six limbs were amputated with 6 deaths, with a mortality of 18.2 per cent. Twenty-eight débridements were undertaken, with 8 deaths, a mortality of 28.5 per cent.

To summarize, the following prophylactic and therapeutic procedures were used in the treatment of gas gangrene, with the indicated mortality: roentgen therapy prophylactic and/or therapeutic—33.3 per cent, therapeutic perfringens antitoxin, 30.9 per cent, Sulfanilamide locally and/or generally—30.8 per cent, prophylactic perfringens antitoxin 10,000 U—29.3 per cent, débridement, 28.5 per cent

prophylactic perfringens antitoxin 1,000—2,000 U—26.3 per cent, amputation, 18.2 per cent.

Despite this inconclusive evidence, it was necessary to formulate a uniform method for treatment of these cases, and the following outline, based on our experience and that of others was evolved.

In addition to the usual care given in all traumatic cases, every patient in whom the deep fascia has been penetrated is considered to be a potential victim of gas bacillus infection and is treated accordingly. Treatment includes a painstaking clean-up with sterile water, green soap and shaving, followed by ether, iodine, and alcohol. The operative field is draped, and a purposeful débridement is undertaken. No nonessential tissue that has been exposed by the injury is permitted to remain. It is imperative that the full extent of the wound be determined and explored. The under surface of the extremity must be inspected for additional injuries or wounds of exit. All foreign material and devitalized bone is, of necessity, sought and removed. The original instruments are discarded. Muscle removed from the wound should be cultured for gas organisms.

I cannot leave this phase of the treatment without emphasizing again the importance of the débridement. Ultimate success or failure hinges more upon this than upon any other aspect of the therapy. A copious warm normal saline irrigation is then used, care being taken that all parts of the wound are flooded with solution. After all bleeding points are ligated, 10 grams of sulfanilamide crystals are placed in the wound if the incision is to be closed. Twice this amount may be used if the incision is to be packed open. Correspondingly smaller amounts should be used in children. The decision as to whether the incision should be closed rests upon so many considerations that I shall only say that the edges cannot be approximated without tension, or if a dead space remains, the wound is left open, with an abundant gauze pack. If a fracture is present or if the wound is near a joint, the part is immobilized by an adequate plaster encasement. Fifteen hundred units of tetanus antitoxin are injected. A prophylactic or thera-

peutic dose of perfringens antitoxin may be given, if the operator has faith in this agent. If there is any impairment of the circulation to the part a sympathetic novocain injection should be given. Henry does this routinely in all cases of potential gas gangrene.

As soon as possible on the day of operation, a postoperative roentgenogram is taken. This checks the position of the fragments if a fracture is present, and serves as a standard for comparison when later roentgenograms are made to determine if gas is present in the tissues. A prophylactic roentgen-ray treatment, as outlined by Kelly (9) should also be given to the involved area at this time. Twelve hours later another film is made to determine if gas has increased in the damaged area, and a second prophylactic roentgen-ray treatment should be given. A third roentgenogram made 24 hours after the injury will definitely determine if a gas infection is present. If this is negative, there is little likelihood that gas gangrene will occur. Six grams of sulfanilamide, or sulfadiazine, should be given daily for the first 48 or 72 hours during this probationary period. The clinical signs and symptoms meanwhile should not be neglected, and excessive pain, swelling, tachycardia, discoloration, or crepitus should point to a gas infection. The roentgenologic diagnosis, however can and should be made before these changes are evident. If gas gangrene develops an immediate débridement, or open amputation, should be performed, depending upon the degree of involvement and the state of the circulation distal to the infection. Roentgen therapy and the sulfonamides should be continued. The latter should be given intra-

venously if a satisfactory level cannot be maintained by the oral route. An erythrocyte count and hemoglobin determination should be made daily followed by plasma or whole blood transfusions as indicated for these patients frequently develop a rapid and severe secondary anemia. An electrocardiogram should be made before the patient leaves the hospital, for severe myocardial damage has been reported following gas infection.

In the treatment outlined an attempt has been made to combine the best elements in our own experience with such suggestions made by others as seem to offer the greatest likelihood of success. This method was instituted slightly more than 3 years ago at the Medical College of Virginia. There was been a great reduction in the incidence of gas gangrene during the past 3 years. This improvement is due in part, no doubt to the restrictions on the use of automobiles and the lowered speed limits. I am sure however that the method now employed in these cases has played a part in this reduction. While it is too early to draw definite conclusions as to the ultimate worth of the method described, we feel encouraged and justified in continuing to use it.

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THE UTERINE CONTRACTIONS ASSOCIATED WITH PROLONGED LABORS

Observations of Uterine Motility made with the Lóránd Tocograph

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THE problem created by the occurrence of prolonged labor is one of the most important met with by the obstetrician. It requires him first of all to determine whether the failure of the patient to deliver in a reasonable length of time is due to disproportion or to inadequate contractility of the myometrium. And the success with which he copes with his problem depends in many instances upon how soon he makes his differential diagnosis.

Moderate degrees of disproportion can be diagnosed by physical examination, or by resorting to the use of roentgen pelvimetry. The efficiency of the uterine contractions, on the other hand, is somewhat difficult to evaluate by physical examination, but this difficulty also can be overcome to a considerable extent by recording the character of the contractions with a Lóránd tocograph (1,2). This is a simply constructed mechanical device which supplies a permanent record of uterine activity measured through the medium of the abdominal wall.

Recently we had the opportunity of studying, with the tocograph, the uterine contractions of a series of patients at frequent and regular intervals throughout labor. The majority of the patients delivered after labors of normal duration. A few, however, experienced unusually long labors. The tocographic records of the patients experiencing long labors exhibited certain characteristics which distinguished them from the records of the patients who delivered in a normal length of time. Since knowledge gained from a study of both sets of records appeared to have clinical as well as academic interest, typical records are presented and discussed in order to illustrate the points in question.

MATERIALS AND METHODS

The uterine contractions of 105 women, who were being delivered vaginally in the Hospital of the University of Pennsylvania, were registered at 1½ to 2 hour intervals throughout their labors with

a Lóránd tocograph. Complete sets of tocographic observations supplied by 3 of the patients in the series, who experienced unusually long labors, form the basis for the present analysis. Other data upon the labors of the 105 patients have been reported upon previously (3, 4).

RESULTS

Labor of normal duration Figure 1 reproduces the tocographic record of a multipara who experienced a labor of 16 hours' duration. She delivered spontaneously an infant weighing 2,730 grams. Her tracings, which are typical of the contraction pattern observed in association with adequate uterine motility, reveal waves of normal height and length, waves which recur at regular intervals, and ones which resemble each other in both size and shape.

The motility associated with labors of good quality and of normal length is characterized by a contraction pattern of such a kind that it is possible, in one's mind's eye to superimpose any wave and its following trough upon either of its adjacent waves and their troughs. The effectiveness of the uterine motility is increased further if the waves are of greater than average magnitude.

Prolonged labor As can be demonstrated in the accompanying graphs, a prolonged labor may be associated with either normal or abnormal uterine motility.

Prolonged labor associated with normal uterine motility Figure 2 reveals the uterine contraction pattern of a multipara who experienced a normal uterine motility throughout her entire labor of 9½ hours' duration.

The prolongation of her labor was due to disproportion which included the existence of (a) an android pelvis, (b) pelvic funnelling with associated unusual prominence of the ischial spines, (c) a posterior position of the occiput which necessitated manual rotation and forceps extraction, and (d) an infant which weighed 4,450 grams.

The tocographic tracings of this patient reveal waves of excellent height, length, and rhythmicity, and ones which resemble each other rather closely in most characteristics.

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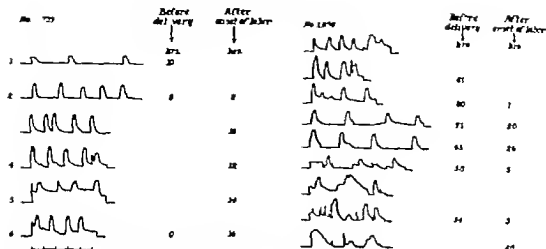


Fig. 3. Tocographic record of normal uterine contractions occurring in labor of 6 hours' duration. Time intervals 3 minutes. Note (a) magnitude, (b) rhythmicity and (c) satisfactory uniformity in size and shape of waves.

Prolonged labor associated with primary uterine inertia. Figure 3 reproduces the contraction pattern of a primipara who delivered herself of an 8,500 gram infant at the 36th week of pregnancy. The infant presented by the breech. This patient experienced an inadequate uterine motility throughout her entire labor of 47 hours' duration.

The contraction pattern of this patient is characterized by (a) waves of small magnitude, (b) ones which vary in size and shape, and (c) lack of a normal rhythmicity of occurrence of successive waves.

Prolonged labor associated with primary and secondary inertia. Figure 4 records the contraction pattern of a primipara who experienced both primary and secondary inertia. Her waves are smaller than those which are typical of normal labor and they have lost their rhythmicity at times, as shown in tracings 4 and 5. From tracing 9 onward there is almost a total absence of any intermittent contraction waves, indicating the existence of a secondary inertia.

EVALUATION OF STUDY

The present observations demonstrate the feasibility of acquiring consistently uniform records of uterine motility with the tocograph at intervals through labor. They indicate, furthermore, that the pattern of contraction is established early and persists throughout labor and that each patient exhibits a pattern which is peculiar to herself.

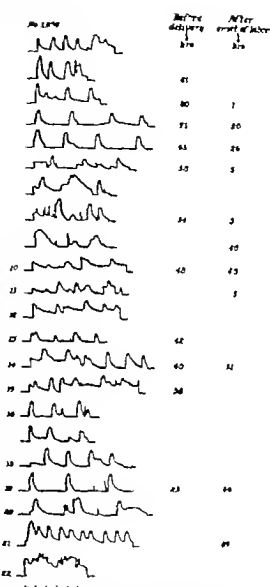


Fig. 4. Tocographic record of normal uterine contractions observed during labor of 9 hours' duration. Time intervals, 3 minutes. Delay in delivery due to disproportion. Note persistence of (a) large waves, (b) average rhythmicity and (c) satisfactory uniformity in size and shape of waves throughout the whole labor period.

At the beginning of labor the patient will reveal either a good or poor type of motility and it is usually the case for the original quality of uterine activity to be maintained throughout the labor.

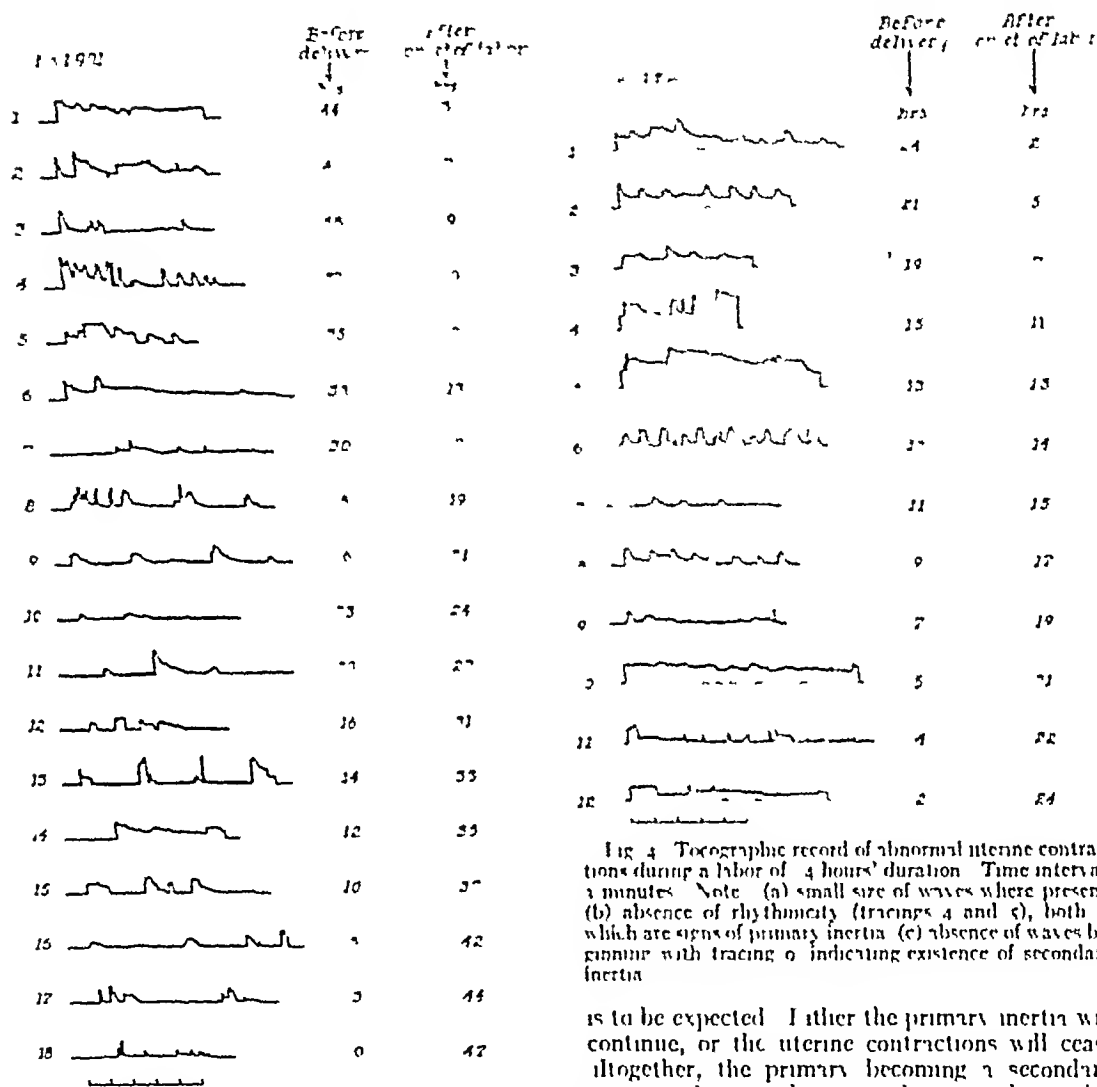


Fig 3 Tocographic record of abnormal uterine contractions (primary inertia) throughout a labor of 47 hours' duration. Time intervals 3 minutes. No evidence of disproportion. Note (a) small size of waves, (b) absence of satisfactory rhythmicity and (c) wide variation in the size and shape of successive waves.

If a satisfactory pattern of contraction becomes established early, a labor of normal duration should be expected in the absence of any evidence of disproportion. If labor is prolonged, with a normal pattern of motility, any delay in delivery is probably due to an undetected disproportion.

If the tocographic record gives evidence of primary inertia early in labor, one of two sequels

is to be expected. Either the primary inertia will continue, or the uterine contractions will cease altogether, the primary becoming a secondary inertia. As yet, the writer has not observed a secondary inertia to follow an earlier normal motility in the absence of disproportion.

From such observations as these, it must be apparent that tocographic recordings made systematically throughout labor can aid greatly in understanding the character of the uterine activity during labor. And an important feature of this aid is that it is acquired early in labor. By virtue of this last fact, the obstetrician is placed in a position where he can distinguish relatively early in labor whether he is dealing with inertia or disproportion. If he finds that he has a case of primary inertia on his hands, by securing tocographic records at intervals, he will then be able

Fig 4 Tocographic record of abnormal uterine contractions during a labor of 4 hours' duration. Time intervals 1 minutes. Note (a) small size of waves where present, (b) absence of rhythmicity (tracings 4 and 5), both of which are signs of primary inertia, (c) absence of waves beginning with tracing 9, indicating existence of secondary inertia.

to discover whether the patient ultimately develops a secondary inertia and just when that occurs. With this information available he will then be in a position to terminate the labor without undue delay.

SUMMARY AND CONCLUSIONS

1. The uterine contractions of 15 patients were registered at 1½ to 2 hour intervals throughout labor with a Lórándi tocograph.

2. The tocographic records of 3 patients who experienced prolonged labors are reproduced.

3. The uniformity in the character of the tracings of a given individual demonstrates the feasibility of recording the uterine contractions at frequent intervals throughout labor.

4. The character of the contraction pattern is established early in labor and with minor modifications persists throughout labor.

5. The contraction pattern of one individual differs significantly from that of another.

6. A prolonged labor may be associated with either a normal or an abnormal uterine contraction pattern.

7. The persistence of a normal contraction pattern throughout a prolonged labor suggests that any delay in delivery is due to disproportion, rather than to inertia.

8. The contraction pattern characteristic of primary uterine inertia is established early in the course of labor.

9. The tocograph will record not only the existence of a primary inertia, but also indicate its degree. Furthermore, regular tocographic tracings will record the first appearance of secondary inertia.

10. From these observations it is concluded that systematic recording of the character of the uterine motility during labor by means of the Lórándi tocograph can aid the obstetrician in the conduct of the labor.

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CONSERVATIVE TREATMENT OF ACUTE INVERSION OF THE UTERUS

HERBERT BURWIG, M.D. I.A.C.S., Buffalo, New York

ACUTE puerperal inversion of the uterus is a comparatively rare lesion with a reported incidence varying from 1 in 740 to 1 in 16,000 (3) deliveries. One can assume, therefore, that the average obstetrician will encounter this serious complication one or more times during his career. Because the author had the opportunity to see 4 acute puerperal inversions of the uterus within a period of 6 months, he feels justified in reporting them.

CASE 1 Mrs. D. S., a primipara, aged 25 years, was delivered spontaneously under chloroform anesthesia of a 7 pound 6 ounce, normal female, after 5 hours of labor. The placenta was delivered 12 minutes later assisted by Credé's method. Repair of a first degree laceration of the cervix followed. When the patient began to bleed, 1 cubic centimeter of ergotrate was given, and the vagina was packed in an attempt to control hemorrhage. Intravenous therapy was started, 1000 cubic centimeters of 5 per cent glucose and 1500 cubic centimeters of whole blood had been given over a period of 8 hours and 3 cubic centimeters of ergotrate when the patient was first seen by the author and the inversion of the uterus was discovered. The patient's blood pressure was now 60/0, and she was in deep shock. The temptation to correct the inversion of the uterus was resisted, and only a firm packing of the vagina around the fundus was done at this time. Stimulants, intravenous fluids, and whole blood were continued, and the patient slowly recovered from shock. Six days later under combined spinal and inhalation (cyclopropane) anesthesia, the inversion was reduced by taxis. The fundus was not packed. Another pint of blood was then given. Four days later the patient voided spontaneously for the first time since her delivery, and the headaches complained of after surgery now disappeared. On the whole, her postoperative course was smooth, with the temperature rising only once to 100.2 degrees on the first postoperative day. A postpartum examination made 6 weeks after her release from the hospital showed the uterus to be normal in every respect, although there was a slight erosion of the cervix which was subsequently cauterized. Six months postpartum the pelvis was found to be normal in every way.

CASE 2 Mrs. L. S., a tripara, aged 20 years, was delivered under chloroform anesthesia of a normal male infant weighing 7 pounds and 15 ounces, after 3 hours of labor. One cubic centimeter of pituitrin was given, and 5 minutes later, by modified Credé method, the placenta was delivered still attached to the uterus which was found to be completely inverted. The patient immediately went into deep shock and began to bleed. The placenta was separated from the uterus, the uterus was restored to the vagina, and the vagina was firmly packed. Intravenous therapy was promptly started and 500 cubic centimeters of plasma, 1000 cubic centimeters of 5 per cent glucose, and 2000 cubic centimeters of blood were given over a period of 6 days postpartum. On the 6th postpartum day, under combined spinal and inhalation (cyclopropane) anesthesia, the in-

version was corrected by taxis and the fundus was packed with plain sterile gauze. The temperature rose to 103 degrees on the first postoperative day to drop promptly to normal and remain so after the packing was removed 24 hours later. This patient received no ergotrate postpartum, but did receive 1 gram of sulfanilamide 3 times a day postpartum, and sulfathiazole after operation. She voided spontaneously for the first time after correction of the inversion. A postpartum examination which was made 4 weeks later showed the pelvis to be normal in every way.

CASE 3 Mrs. M. B., a secundipara, was delivered under chloroform anesthesia with outlet forceps of a normal male infant weighing 7 pounds and 6 ounces, after 3 hours of labor. A repair of a first degree perineal laceration followed. Six minutes after the delivery the placenta appeared assisted by Credé's method. One cubic centimeter of pituitrin was given. The patient began to bleed and promptly went into shock. The inversion was discovered, and the vagina was firmly packed around the uterine fundus to control the hemorrhage. The blood pressure dropped to 86/40, the patient was restless, the pulse rapid and thready. Intravenous therapy was promptly started and 500 cubic centimeters of plasma and 2000 cubic centimeters of whole blood were given over a period of 5 days. This patient was able to void on the first postpartum day. Despite 1 gram of sulfadiazine 3 times daily, this patient ran a low grade septic course, with the temperature rising to 102.2 degrees on the 3d postpartum day but nevering 100 degrees until 2 days before her dismissal from the hospital. On the 7th postpartum day the inversion of the uterus was corrected by taxis under combined spinal and inhalation (cyclopropane) anesthesia, and 8 days after surgery she was discharged from the hospital. A postpartum examination made 4 weeks later showed the pelvis to be perfectly normal in every way. Fourteen months later this patient was delivered again, on this occasion without any complications.

CASE 4 Mrs. J. S., a primipara, aged 23 years, was delivered under chloroform anesthesia, after 10 hours of labor, with outlet forceps, of a normal 7 pound female infant. Following repair of the midline episiotomy, the abdomen was palpated to ascertain whether or not the placenta had separated and the fundus could be felt. Just then the placenta appeared at the vulva and was delivered (10 minutes after the delivery) with gentle traction upon the cord. The diagnosis of complete inversion of the uterus was then confirmed. However, the patient showed no signs of shock and had not started to bleed. She was therefore, promptly reanesthetized and the inversion was corrected by taxis. She was given 1 cubic centimeter of ergotrate and was returned to her room in good condition. Her temperature rose to 101 degrees on the 3d postpartum day, to subside to normal and remain so after her 5th postpartum day. Sulfathiazole—7 grains, 3 times daily—was given until her dismissal from the hospital on the 11th postpartum day, when she was fully recovered. A postpartum examination made 4 weeks later showed the pelvis to be normal in every way. Sixteen months later, this patient is again pregnant and approaching term.

Although no criteria are available to lead one to anticipate acute inversion of the uterus that carries with it a mortality rate (3) of 10 to 43 per cent much has been written about the etiology of this obstetrical complication. Mismanagement (7) of the third stage of labor particularly has been stressed, perhaps to the point which deters some from reporting such accidents. In the management of the uterine inversion authors (6) generally agree that in the absence of shock the inversion may be corrected at once but that in the presence of shock, shock must be treated first promptly and effectively. From this point on authors differ. Some favor conservative treatment and correct the inversion by taxis from below a few hours, a few days, or even a few weeks later. Others favor operative treatment a few weeks or months later either vaginally or abdominally (4, 5, 9) either to correct the inversion of the uterus or to remove the uterus itself. Some authors have advocated the administration of adrenalin (1, 10) others, spinal anesthesia to assist in relaxing the constricting cervix. The author has had no experience with the former and added just enough inhalation anesthesia to the latter to allay the patient's fears. No cases of chronic inversion of the uterus were seen and therefore no attempt is made to discuss them. Although 4 cases constitute but a small series, nevertheless the successful termination of each following a definite plan of management (and it is readily admitted that none of these individual steps are original) may help to establish a standard routine for the treatment of acute postperal inversion of the uterus, as follows:

1. If the patient is not in shock, manipulative correction of the inversion of the uterus under deep anesthesia may be attempted immediately.
2. If the patient is in shock, the shock is treated first and manipulation is delayed until the patient has recovered from it.
3. Hemorrhage is to be controlled by firm packing of the vagina against the inverted fundus, and blood loss compensated with repeated transfusions of whole blood, plasma, and intravenous fluids.
4. The patient is to be catheterized if unable to void spontaneously.
5. Some form of ergot may be given to hasten involution.

6. Some one of the sulfonamides may be given prophylactically to guard against infection.

7. About 1 week postpartum, with the patient recovered from shock, the uterus partly involuted, (now approximately the size of an 8 ounce glass tumbler) under combined spinal and inhalation anesthesia, the inversion can be corrected by taxis, i.e., squeezing the fundus as one would a rubber ball held in the palm of one's hand.

8. The uterine cavity may or may not then be packed to prevent reinversion of the uterus. (The author omitted this step in 3 of the 4 cases described in this paper.)

CONCLUSIONS

1. Acute inversion of the uterus may be the result of uterine atony, pressure on the fundus above, traction on the cord from below. It may also be wholly spontaneous.

2. In the absence of shock the inversion may be corrected at once.

3. In the presence of shock all manipulative efforts are to be deferred until the patient has recovered from it.

4. Under anesthesia, preferably spinal anesthesia, the inversion is corrected by taxis.

5. This conservative treatment made it possible for 2 of these 4 patients to have another baby. Two of these patients have since been delivered again with perfectly normal labors and postpartum courses.

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RIGHT RECTUS GRIDIRON INCISION IN CONGENITAL HYPERTROPHIC PYLORIC STENOSIS

HERBERT H DAVIS, M D, F A C S, Omaha, Nebraska

THE purpose of this report is to describe a new incision for use in the Fredet-Rammstedt type of operation for congenital hypertrophic pyloric stenosis. Previously three main types of incision were used in this operation, namely, the high right rectus, midline, and right subcostal gridiron incisions. Each of these has definite objections. The high right rectus incision, the one employed most universally, is easy to make and gives good exposure, however, eventration is too common a complication. To guard against this, tension sutures often are used and are left in place until the wound is firmly healed. By this time marked foreign body reaction and suppuration about these sutures usually occur. The same objections apply to a midline incision.

To avoid these complications a right subcostal muscle splitting incision may be used. In this incision each of the three abdominal muscles are split in the direction of their fibers, and this procedure insures a stronger abdominal wall and makes unnecessary the use of tension sutures. However, this incision is difficult to make inasmuch as the muscles are thin and not easy to identify. Moreover, as the incision is too far lateralward, it does not permit good exposure of the pyloric mass.

A high right rectus gridiron incision has many advantages: it gives a strong abdominal wall as all layers are split in the direction of their fibers—it is a gridiron type of incision, it gives good exposure as it is directly over the pyloric end of the stomach, as the skin lines of the abdominal wall run transversely in this region, it leaves a finer scar, it is not necessary to use tension sutures, the skin sutures can be removed early so there is not much tissue reaction about them, no binder is necessary.

From the Department of Surgery, University of Nebraska College of Medicine.

The technique used in making this incision may be described as follows. Over the upper part of the right rectus muscle a short transverse incision is made through the skin, subcutaneous fat, and anterior sheath of the rectus. The deep surface of the rectus sheath is dissected from the rectus muscle so that these flaps can be retracted upward and downward. The rectus muscle is split longitudinally and retracted to expose the posterior sheath of the rectus. This latter layer with the peritoneum is incised transversely. In closing the wound each of these layers is sutured separately, the peritoneum with the posterior sheath of the rectus, the rectus muscle itself, the anterior sheath of the rectus, and finally the skin.

Meredith uses a right rectus incision but splits the posterior rectus sheath transversely. As far as I know this is the first time that the right rectus gridiron incision as here described has been advocated and used. It is not difficult to make, gives good exposure, and leaves a firm abdominal wall.

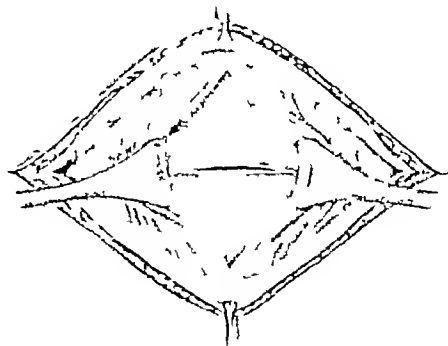


Fig. 1. Right rectus gridiron incision. Transverse incision through skin, fat, and anterior sheath of rectus, vertical incision through rectus muscle and transverse incision through posterior sheath of rectus and peritoneum.

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ON THE PRONOUNCEMENT OF CANCER

*'Oh, what a tangled web we weave, when first we
practise to deceive! Sir Walter Scott*

ONE of the most unpleasant and delicate duties to confront a physician is the pronouncement of the existence of a cancer. The unfortunate odium that has long attended this disease and the false legends of its incurability have conspired to make the occasional patient accept this diagnosis as a verdict worse than death. The ability to receive such unwelcome news with fortitude and equanimity is an attribute denied the majority of individuals. Inasmuch as the qualities of courage, intelligence, and emotional stability are so variable in humans and because it is the physician's task to treat the mind and spirit as well as the body, no set rule can be formulated for acquainting all cancer patients with the diagnosis and prognosis of their ailment.

This discussion would be unnecessary if it were the universal practice of doctors to make

an immediate, direct, and blunt declaration of this diagnosis and to permit the patient and his family to react and adjust themselves as well as possible to this seeming catastrophe. The protagonists of this method of handling the problem might well quote one of the aphorisms of Johann Kaspar Lavater who said: "He who, when called upon to speak a disagreeable truth, tells it boldly and has done is both bolder and milder than he who nibbles in a low voice and never ceases nibbling." It is surprising how much vicarious strength of character some physicians possess for suffering their patients' diseases. One young physician, proud and self-righteous in his avowed habit of telling all the truth, was not deterred by the suicide of one patient, but when another patient jumped from the twelfth story and a third became violently insane while still in the hospital, he was ready to consider the advantages of psychological management over the bare, unvarnished truth. A psychiatrist might point out that the three patients cited had impaired mental backgrounds in the first place and might have behaved similarly to other shocks; nevertheless this does not lessen the obligation of the physician. We cannot limit the occurrence of cancer to the brave and the strong. Furthermore, a patient endowed with the most heroic stoicism at the time of receiving the pronouncement of cancer may after a few months of insomnia, constant pain, and progressive disability become almost another individual, desperate and craven, who has lost his courage but unfortunately not his memory.

The family physician who knows the personality, the character, and the familial environment of the patient seldom undertakes

ing questions from the patient. The average patient expects the worst and in the light of the treatment planned for him is naturally and reasonably dissatisfied or hesitant with any ambiguous explanation or one that doesn't admit the serious character of his disease. This doubt can be dispelled by asserting in the beginning that the patient does have a "tumor" endowed with dangerous potentialities. Proceed to explain that without early and appropriate treatment this tumor is capable of changing its localized status and may become generalized. Encourage the patient by the fact that the tumor is amenable to therapy and rightly defend the major form of treatment advocated as the procedure most likely to offer the patient the safety he wishes and deserves. The word cancer is intentionally omitted from the conversation. The average patient realizes that the disease is really cancerous or perhaps precancerous and agrees to treatment at the same time gratefully appreciating the consideration of the physician in not openly labelling the tumor as "malignant." By avoiding the use of the word "cancer" the patient may always cherish the hope that the tumor had not become cancerous as yet; the patient would rather retain this thread of healthy doubt and uncertainty than to have once and forever the finality that

goes with the pronouncement of cancer. As time goes by the patient becomes fully cognizant of the nature of the disease he has and a tacit understanding develops between him and the physician during the observational years that follow.

Queries concerning prognosis follow the diagnosis as the night the day. A frank discussion of the outlook in any individual case is fraught with certain hazards. A recital of percentage figures for operative mortality and five year survivals, regardless of how good they seem to the professional mind are not particularly reassuring to the patient as they always fall short of perfection. After all he reasons, I may be one of the fatalities or failures. No cancer is so slight as to be considered insignificant and many cancers apparently hopelessly advanced are sometimes controlled; therefore, the physician who cannot always guide the many intangible influences that may render the early cancer incurable and the advanced cancer controllable should be most cautious in guaranteeing a cure or dwelling on the futility of treatment respectively. The patient's family will never forgive a guarantee of cure that failed, and the patient will not let the physician forget a pronouncement of incurability if he is so fortunate as to survive.

GEORGE T. PACK

esting, particularly for one who retains remnant of his Greek.

In the chapter on Byzantine gynecology from the fourth to the seventh century we find an interesting consideration of the development of gynecology after the separation of the Roman Empire into the Eastern and the Western Empires. A résumé of the work of Paul of Aegina which gives many of the remedies used or derived by him is one of the most interesting portions of this part of the work. This is followed by discussion of the information found in the Arabian Medical Manuscripts. Here we find the names of Rhazes, Avicenna, Albercasli, and Serapion the Elder with a brief consideration of their lives and works.

The Mediaeval period and the School of Salerno provide an interesting section of the book. Those who believe that medicine and theology have little in common will be interested to learn that in the year 580, at Merida, bishop did laparotomy for a retained fetus in ectopic pregnancy and that the teacher of St. Thomas Aquinas, Albertus Magnus, Bishop of Ratisbon, wrote a medical treatise entitled *Secreta Mulierum*, which, as the author says, is not without an occasional accurate clinical observation. Trotula's treatise is mentioned and its title page reproduced.

The presentation of the beginnings of the study of the anatomy of the generative tract is given somewhat at length with number of illustrations from the old authors. Vesalius, Bartolomeo Eustachio, Jacques Dubois, and Matteo Testico Colombo all appear in the course of the chapter. Admirers of Paré will find numerous allusions to him and a considerable discussion of his work in the chapter concerning Renaissance Gynecology.

It is not possible to mention the large number of well known names which appear in the chapter on the gynecology of the seventeenth century but the story is an interesting one and number of illustrations accompany it from various of the old works which are mentioned.

The chapter which deals with the gynecology of the eighteenth century is a long one and gives an excellent view of this period. The names of all of the workers whom we have been accustomed to associate with that period of the history of our specialty will be found together with those of some with whom many readers of the book may not have been familiar.

The author has done large amount of research for the wealth of detail which the book contains could be gotten together in no other way. The bibliographies are ample and contain sufficient references to open the door to the literature of medical history to anyone who is interested in further study of the subject.

This book is an addition to works dealing with medical history and one which will be of value to all those in the field of gynecology and obstetrics who are interested in the men and the practice of former ages.

W. C. DEXTER

THE textbook *Röntgenographic Technique* by Rhinehart has served as a standard reference for a large number of technicians over a period of years. It has also proved useful to the roentgenologists.

The new edition has been revised and minor additions have been made to bring it up to date. There has been some rearrangement of material, but no important changes. There are certain details of technique which have been omitted. These deal with highly technical procedures, such as fluororöntgenography, kymography, and laminagraph which could have been included.

On the whole, however this book continues to serve a very useful purpose.

R. Q. WELLY

THE extremities, abdomen, perineum, and pelvis are covered in volume I of *Atlas of Anatomy* by J. C. Bollen Grant. It contains 71 illustrations of which 22 are in color with 49 in three or four colors. The labeling and position of each illustration on the pages of this text give the immediate impression of clarity without the cluttering of illustration legend, and labeling which make most atlases a difficult source for desired detail.

Accuracy is obtained by retouching actual photographs of dissection. The plates give that most essential characteristic of third dimension in a most satisfactory manner. This is also achieved through original and unique dissection through most of the large joints. An atlas of surgery should be selection of plates which demonstrate the layers as encountered by dissection of the respective part. This is achieved in this text.

Although the text is unusually complete this reviewer regrets the absence of section through the hand showing the mid-palmar and thenar spaces.

This atlas can certainly be well recommended to all students of clinical anatomy and to surgeons.

SUMNER J. FORTMEYER

THE love of life is next to the love of our own face and thus the mutilated cravo for help (Sutural Samhita). Development and improvement in plastic surgery of the face are always important and valuable especially as applied to the re-forming of functioning lids with protection to the globe and preservation of vision. Therefore the cravo, cravo understood thesis, *Reconstruction Surgery of the Eye Lids* by Wendell L. Hughes, illustrated clearly with diagrams and photographs co-ordinated with the text is most timely in the present period of multiple mutilations.

The chapters take up in sequence replacement of skin defects with and without pedicle reconstruction.

RECONSTRUCTION SURGERY OF THE EYE LIDS by Wendell L. Hughes, M.D., F.A.C.S., M. Peabody, Inc., Boston, 1941. 112 pages, 112 illustrations, 112 plates. \$5.00. **RECONSTRUCTION SURGERY OF THE EYE LIDS** by Wendell L. Hughes, M.D., F.A.C.S., M. Peabody, Inc., Boston, 1941. 112 pages, 112 illustrations, 112 plates. \$5.00.

REVIEWS OF NEW BOOKS

tion of the conjunctival layer, of the tarsus and most completely the author's method of blepharopoeisis or replacement of the entire lid. In each section a review of the historical development is followed by a careful description of repair most used at the present time.

The author considers free skin grafts quite satisfactory when the skin is taken from the upper lid to replace defects in the lower. An area 2 by 3 centimeters may be transferred. Skin from other parts of the body is used when necessary but is less satisfactory even when accurately removed by means of the dermatome for color and texture and pliability differ from the original.

Conjunctival grafts are of great importance in protecting against or correcting symblepharon. Dr. Hughes prefers transfer of a conjunctiva when possible, otherwise resorts to buccal mucosa. The mucous membrane may be pregrafted into a flap.

Reports on cases numbered 5, 6, 9 and 11 are very valuable because the entire lid structure was replaced. In case 9, following complete destruction of the lower lid, a tarsoconjunctival flap was brought down from the upper lid and a skin flap from the cheek undermined and slid up, the eye was closed by adhesions between upper lid margin and the edge of the skin graft. Later a lower lash line was inserted using a strip from the opposite brow and still later new lid margins were produced between the lines of laceration. Cosmetic and functional results were excellent. Protection of the globe was accomplished which organ would have been damaged otherwise by exposure. Seven movie films are available covering the described surgery.

This book will prove of value to anyone who is developing his technique of surgery of this region.

EARLE B. FOWLER

THE author of *Kinetic Bandaging* divides the body into a series of three basic geometric structures: ovoids, cylinders, and truncated cones. Thus a few fundamental principles are applied to these three involved when bandages are applied to these three basic figures. By acquiring skill in the application of dressings to these elemental units of structure the bandager is able freely to move from one part of the body to another with the utmost ease. This flowing and ready movement from one region to another, until any or all parts of the body surface are covered, without the necessity of memorizing a multiplicity of individual bandages is referred to as "kinetic bandaging."

The type is large and on good quality paper making for easy reading. Descriptions are clear and the step by step illustrations leave little chance for confusion. Each turn of bandage is numbered. Bandaging of all parts of the body are described and illustrated but covered under the three basic geometric designs. For example the hand, finger tips and tips

of the toes are ovoids, the neck, trunk, wrist, and lower legs are cylinders while the forearms, arms, legs and thighs are truncated cones.

It is surprising to see illustrations of such neat bandaging and then to find that in figure 89, page 57, illustrating the fixation of the terminal end of a roller bandage that the upper and lower borders are left free to become ragged and untidy when folding these borders under towards the midline of the bandage, tapering the end to more or less of a point which could be entirely covered with adhesive, would give a neat and graceful termination. The same is true for figures 90 and 91 on page 58 where the terminal end of the bandage is made secure with a safety pin. These criticisms may seem trivial but the author is striving for neat as well as efficient bandaging. All but the last illustration in figure 5, page 12, are confusing to the reviewer since they give the erroneous impression that the roller bandage is to be carried to the left rather than to the right.

This profusely illustrated book on bandaging is indeed timely. The author expresses the hope that it will prove of value to the Army and Navy Medical Corps personnel, Red Cross workers, and others directly or indirectly concerned with the care of the wounded. Certainly it will be of great value to any person required to teach or practice bandaging.

EAPL O. LATIMER

THE small, pocket sized, *Oxford War Manual of the Services*, is well adapted for its purpose. That is, the fundamentals of the common diseases of the ear, nose, and throat are presented in a brief manner for the physician in the war service whose training has been for fields other than the ear, nose, and throat.

It is written in a chatty, abbreviated manner, largely from the symptomatic viewpoint so that the medical officer would recognize the more common ailments and be able to give the usual first aid. The illustrations are rough sketches but adequate in most instances. Surgical technique has not been stressed except for the more urgent procedures such as tracheotomy or the opening of abscesses and so forth.

The author has used excellent judgment in a conservative way in his various therapeutic measures. The book, as a whole, is readable and authentic in the brief territory covered.

H. C. BALLEGEER

AS is indicated by the authors in the foreword to the book, *A Hundred Years of Medicine* by Haagen-Sen and Lloyd, is written with an appeal more to the layman than the physician.

The book is divided into four general divisions with the first dealing with the history of medicine up to a hundred years ago and is almost entirely

historical in nature. The second division is devoted to medical sciences as contrasted to the surgical aspect. The third section takes up the changes that apply more specifically to surgical procedures. The fourth part considers the many social aspects of medicine.

Under the second division consideration is given to the early history of pathological and bacteriological research, the cure of tuberculous, a study of the vitamins, and the chronic diseases. The third division considers the progress from McDowell's first ovariotomy through early anesthesia, the control of infection associated with operation, the prevention of surgical shock, the discovery and uses of radium energy, and some of the more important procedures in the specialized types of surgery. A short and very

interesting chapter is devoted to the origin and development of the trained nurse.

The fourth division of the book is given to the social aspect of medicine and includes such subjects as cost of medical care, sickness insurance and study of the various income levels and the amount expended for medical care. It also includes an interesting chapter on the development of medical education in schools and hospitals.

The authors have made a very valuable addition to the history of medicine from its early feeble effort to the present high grade type offered to the public. The book, however, will appeal more to the lay reader than the physician, to whom most of the material is already known. It is a valuable addition to any library.

WILLIAM G. ALFORD

BOOKS RECEIVED

Books received are acknowledged in this department, and each acknowledgment must be regarded as sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

MEDICAL RADIOGRAPHIC THEORY. Prepared by The Technical Service Department of General Electric X-Ray Corporation. Edited by Glenn W. Filler, Director. Springfield, Ill. and Baltimore, Md. Charles C. Thomas, 1933.

A MEDICAL BIBLIOGRAPHY: A CHECK LIST OF TEXTS ILLUSTRATING THE HISTORY OF THE MEDICAL SCIENCES. By Fielding H. Garrison, M.D., and Leslie T. Martin. London: Griffin & Co. 1933.

NANCY'S GYNOCOLIC THERAPY. By John Fruetha Ritter, M.D. Caldwell, Idaho: The Carson Printers, 1930.

ILUSTRACIONES GYNOCOLICAS. By Eduardo Belcher. Córdoba, Argentina: Universidad Nacional de Córdoba, 1933.

THE MODERN MEDICAL SURVEY OF COLETTES. By J. Arnold Barger, M.D., M.S., F.A.C.P. Springfield, Ill. and Baltimore, Md. Charles C. Thomas, 1933.

THE 1933 YEAR BOOK OF INDENTURE TO ORTHOPEDIC SURGERY. Edited by Charles F. Palmer, M.D. Chicago: The Year Book Publishers, Inc. 1933.

EMERGENCY YOGA: A BOOK FOR EMERGENCY NURSES AND PROSPECTIVE FARMERS. By Mario A. Castelli, A.B., M.D., F.A.C.S. and Audrey Wale. New York: The Macmillan Co. 1933.

THE ANTHROPOLOGICAL HANDBOOK OF ROENTGEN DIAGNOSIS. By Alfred A. deLoraine. A.B., M.A., M.D. Chicago: The Year Book Publishers, Inc., 1933.

WAS WOMEN AND INJURY. Edited by R. M. Wood, F.R.C.S., D.O. SHERWOOD, O.B.E., M.S., F.R.C.S., and Ernest FLETCHER, M.A., M.B., F.R.C.P. With foreword by Lord Horder. 2nd ed. Baltimore: The Williams & Wilkins Co. 1933.

THE NATIONS OF THE SIXTY-FOURTH MEETING OF THE AMERICAN SCIENTIFIC ASSOCIATION: Held at Netherlands Plaza Hotel, Cincinnati, Ohio, May 3-4, 1933. Edited by Walter Foster Lee, M.D. Vol. 6. Philadelphia: J. B. Lippincott Co. 1933.

AMERICAN COLLEGE OF SURGEONS

PLANS FOR 21 WAR SESSIONS IN 1944

THE American College of Surgeons announces plans for a series of one-day War Sessions to be held in 21 cities, well distributed throughout the United States and Canada, in February, March, and April, 1944.

The cancellation of the 1943 Clinical Congress makes it especially desirable to continue the War Sessions as means of informing the profession concerning the developments in medicine and in the conditions affecting medical practice and hospital care which have been rapidly occurring under the pressure of wartime events. The enthusiastic reaction to the similar series of meetings held in 1942 and 1943 is another reason for planning the War Sessions in 1944. Advancements in military medicine and developments in civilian medical research and practice under the spur of the war emergency will provide abundant material for an intensely interesting program for each of the 1944 meetings.

As in the two previous years, the College is assured of complete co-operation by the official war services of the Government. The United States Army, Navy, Public Health Service, Veterans Administration, Procurement and Assignment Service, and the Office of Civilian Defense, are assigning representatives to participate in the meetings. In the hospital conferences, such agencies as the War Production Board, the War Manpower Commission, the American Red Cross, and the Division of Nursing Education of the United States Public Health Service which has jurisdiction over the United States Cadet Nurse Corps, will be represented. Medical service in industry and the work of committees of the medical division of the National Research Council will also be prominently featured in the scientific program. The developments in civilian medical and surgical practice will be presented by national authorities, some from within the area covered by the meeting, and others who come from greater distances.

For the four meetings which are to be held in Canada, members of the Canadian Medical Service who have recently returned from overseas, as well as those who are serving in the country, will participate. The present outlook is that a three-day refresher course for members of the military

services (Army, Navy, and Air Force) will be timed directly to follow the War Sessions in Winnipeg, thus permitting those attending the course to participate also in the College meeting by coming a day earlier. The Montreal, Toronto, and Vancouver meetings also promise to be well attended and the local profession in each city has expressed keen interest in the arrangements. The committees in charge of the various War Sessions in Canada have expressed the hope that the Surgeons General of the United States Army and Navy may participate in their meetings, and the Surgeons General are hopeful that they may be able to be present at some of the War Sessions at least.

PURPOSES OF THE WAR SESSIONS

One of the primary purposes of the War Sessions is to bring directly to the physicians and to hospital personnel, in a convenient location, information from authorized representatives of the various federal services that will help them to understand the immediate problems of these services and enlist their co-operation in attaining the objectives that will continue to help in winning the war. In turn, doctors and hospitals are provided opportunities to present their problems directly to officials who can be of help in their solution.

An outstanding benefit derived from the War Sessions has been the effecting of better mutual understanding and co-operation between the various government services and the medical profession and hospitals in general. The recruitment of medical officers for the military services has been furthered through the meetings, while at the same time due emphasis has been placed upon the necessity of maintaining adequate medical and hospital service for the civilian sick and injured.

The War Sessions are designed for the benefit of physicians and surgeons at large, medical officers of the Army and the Navy, residents, internes, medical students, and executive personnel in hospitals, and, of course, for junior candidates and fellows of the American College of Surgeons.

Those who plan to attend may select the meeting in place or time is most convenient,

regardless of the states and provinces which, for the purposes of organization, are designated on the list as participating in a given meeting.

The general outline of the program for each of the meetings is shown in the accompanying schedule. Some adaptations of this outline will, of course be necessary in the programs for the meetings in the four cities of Canada. Canadian officials and fellows of the College have formed committees to plan the programs for the meetings in Canada.

It is planned to feature among the scientific presentations at every meeting the experiences of physicians and surgeons who have been on active duty in combat zones.

Suggestions for subjects to be included in the programs, discussion to be from the standpoint of actual experience are as follows: types of wounds of modern warfare; evaluation of the use of sulfa compounds; compound injuries; states of treatment of burns; treatment of fractures; states of penicillin; aviation medicine and surgery; transportation of the wounded; rehabilitation; industrial medicine; endemic and epidemic diseases; and civilian surgery.

The programs will include panel discussions and round table conferences in addition to the formal presentations. Since physicians and surgeons in civilian life are too busy to prepare clinical programs, demonstrations in hospitals will be omitted as has been the practice in the previous War Sessions. Many subjects of nonmilitary nature and some that have come to the forefront in war medicine but that also affect civilian practice, will be discussed at each meeting.

PROCUREMENT AND ASSIGNMENT SERVICE

At the luncheon meeting, vital problems pertaining to the supply of medical officers for the Army with special reference to the g-o-g plan for Internes, assistant residents and residents and the allocation of nurses, will be presented by representative of that service. Both in the United States and Canada there will be for the duration of the war many problems to meet in supplying physicians and nurses for the military services as well as for civilian practice.

CIVILIAN DEFENSE

The United States Office of Civilian Defense, in a release dated December 8, announced that 93 hospitals and medical schools scattered throughout the country have completed formation of affiliated units of civilian physicians which will be available to either the Office of Civilian Defense or the Army in the event of need for setting

up emergency hospital facilities in their respective areas. Each unit is composed of 15 physicians, surgeons, and other specialists, and forms a balanced professional staff. The Office of Civilian Defense will use the units to supplement the staffs of "emergency base hospitals" located in relatively safe zones on the fringes of critical areas in case it is necessary to transfer civilian patients to these hospitals because of emergency in such areas. The units will be called upon by the War Department to staff extemporized hospitals should there be a sudden influx of battle-front casualties, or some other extraordinary military necessity requiring hospitals and physicians beyond the immediate capacity of the Army in any particular locality.

To discuss this and other developments which may arise between now and the dates of the War Sessions, the programs in both the United States and Canada will include the subject of civilian defense.

Series of motion picture films of surpassing interest and value on medical and surgical subjects have been produced by the United States Army and the United States Navy. Those in attendance at the War Sessions will be privileged, through the courtesy of the Army and the Navy to view these films which include such subjects as evacuation of the wounded, treatment of fractures, effects of treatment of victims of bomb blast and newer methods of treating burns and their wounds.

Intensive study of methods of relieving the difficulties under which hospitals are laboring in wartime is planned for the hospital conference to be held simultaneously with each War Session. Adjustments to the new g-o-g plan in the United States which will then have been in effect for several months, will be discussed. The importance of maintaining graduate training programs in medicine and surgery will be emphasized. The new United States Cadet Nurse Corps and its effectiveness in relieving the shortage of nurses, and the procurement and assignment program for allocation of nurses, will be among the subjects covered. Other subjects will be the accelerated program of nursing education, the extent to which nurses may safely be permitted to perform duties formerly delegated to internes and other physicians, the extent to which nurses aides should be allowed to perform tasks formerly delegated to nurses, the use of volunteer workers in various departments of the hospital, purchasing and maintenance problems, training programs for new personnel, meeting increased demands for hospital service, maintenance of high

standards of service, and preparation for post-war adjustments. Similar programs covering hospital problems in Canada, will be formulated in co-operation with Canadian hospital executives.

The program for each dinner meeting will consist of an open forum for the purpose of introducing for informal discussion any and all subjects presented during the day, together with other problems of interest to the medical and hospital professions. The participants in the

day's program will serve as a panel of experts in this forum.

Well in advance of the War Sessions, programs will be mailed to physicians and hospitals in each area. Announcements will also be published in the medical and hospital journals, so that ample opportunity will be provided for the making of reservations for transportation and for hotel accommodations, the need for both of which, of course, will be minimized by the local character of the meetings.

PROGRAM FOR ONE-DAY WAR SESSIONS IN THE UNITED STATES

Preliminary Program for the Medical Profession

- 8 30-9 30 a m Motion Picture Films Special showing of official U S Army and U S Navy films on medical and surgical subjects Evacuation of the Wounded, Treatment of Fractures, Bomb Blast Injuries, Burns, Wounds, etc.
- 9 30-10 30 a m Report by representatives of the U S Army who have been on active duty abroad
- 10 30-11 30 a m Report by representatives of the U S Navy who have been on active duty abroad
- 11 30-12 00 noon Report on measures for the control of endemic and epidemic diseases by a representative of the U S Public Health Service
- 12 15-2 00 p m Luncheon Conference on current problems of the U S Procurement and Assignment Service Presentation by a representative of the Service
- 2 15-5 00 p m Three scientific presentations by medical members of the armed forces and by civilian members of the medical profession Scientific presentation by a representative of a medical service in industry Presentation of the program of the U S Veterans Administration
- 5 00-5 30 p m The need for protective services in time of war by a representative of the U S Office of Civilian Defense
- 6 30-9 30 p m An open forum with all participants in the day's program as the panel of experts Any and all subjects which have been presented during the day, together with other problems of interest to the medical and hospital professions, to be open for discussion Dinner meeting

Preliminary Program for Hospital Conferences

- 8 30-9 30 a m Motion Picture Films Special showing of official U S Army and U S Navy films on medical and surgical subjects Evacuation of the Wounded, Treatment of Fractures, Bomb Blast Injuries, Burns, Wounds, etc.
- 9 30-11 30 a m Overall analysis of wartime hospital problems and how they are being solved
- 11 30-12 00 noon Report on measures for the control of endemic and epidemic diseases by a representative of the U S Public Health Service
- 12 15-2 00 p m Luncheon Conference on current problems of the U S Procurement and Assignment Service Presentation by a representative of the Service
- 2 15-5 00 p m Round Table Conference on "Problems Affecting Wartime Hospital Service" Procurement and Assignment Service—The 9-9-9 plan for internes and residents, U S Public Health Service—U S Cadet Nurse Corps, American Red Cross Volunteer workers, War Manpower Commission—training courses, War Production Board—hospital equipment and supplies, Office of Price Administration—food rationing, American Hospital Association—Wartime Service Bureau, American Medical Association—education, American College of Surgeons—hospital standards
- 5 00-5 30 p m Need for protective services in time of war by a representative of U S Office of Civilian Defense
- 6 30-9 30 p m An open forum with all participants in the day's program as the panel of experts Any and all subjects presented during the day, together with other problems of interest to the medical and hospital professions, to be open for discussion Dinner meeting

SCHEDULE FOR 1944 WAR SESSIONS

Date	City	State, Province	Hotel Headquarters
Monday February 29	Windsor	Manitoba, Saskatchewan	Fort Garry
Thursday March	Manneapolis	Minnesota, North Dakota, South Dakota	Norfolk
Saturday March 4	Des Moines	Iowa, Nebraska, Missouri	Fl. Des Moines
Monday, March 6	Chicago	Illinois, Wisconsin	Stevens
Wednesday March 8	Cincinnati	Ohio, Kentucky, Indiana, West Virginia, Tennessee	Netherland Plaza
Friday March	Detroit	Michigan	Statler
Monday, March 9	Rochester	New York State	Seneca
Wednesday March 5	Toronto	Ontario	Royal York
Friday March 7	Montreal	Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland	Mount Royal
Monday March 20	Springfield	Massachusetts, Maine, New Hampshire, Vermont, Rhode Island, Connecticut	Kimball
Wednesday March	Philadelphia	Pennsylvania, New Jersey, Delaware	BeSene Stratford
Friday March 24	Baltimore	Maryland, District of Columbia, Virginia, North Carolina	Lord Baltimore
Monday March 27	Jacksonville	Florida, Georgia, Alabama, South Carolina	George Washington
Friday March 3	San Antonio	Texas, Louisiana, Mississippi, New Mexico, Mexico	Gunter
Tuesday, April 4	Tulsa	Oklahoma, Kansas, Arkansas, Colorado, Wyoming, Western Nebraska	Mayo
Friday April 7	Denver	Utah, Southern Idaho, Washington, Northern Idaho, Oregon, Montana	Cassopolitas
Tuesday, April	Salt Lake City	Utah, Southern Idaho, Washington, Northern Idaho, Oregon, Montana	Utah
Friday April 4	Spokane	British Columbia, Alberta, Northern California, Nevada, Southern California, Arizona	Da report
Tuesday April 8	Vancouver		Vancouver
Monday April 24	San Francisco		Mark Hopkins
Thursday April 27	Los Angeles		Baltimore

SURGERY

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ABDOMINAL WOUNDS IN THE WESTERN DESERT

W H OGILVIE, M A , M D , M Ch (Oxon), F R C S , F A C S (Hon), F R C S (C) (Hon),
Major-General, R A M C London, England

THE surgery of abdominal wounds has been unduly dramatized. Robbed of histrionics, it still remains an important aspect of forward surgery, particularly in mobile war. It is important because, without early and expert operation, the majority of patients die, because skilled preoperative and postoperative care, the surroundings and accessories that they demand, and the administrative foresight that makes them possible are as important as the operation itself, and because the lives saved by operation are nearly always useful ones. There are few chronic abdominal invalids—at any rate among soldiers. A number of men who were wounded in the belly at Alamein marched with the Eighth Army into Tunis.

I have always been interested in this branch of War Surgery, and during my visits to forward surgical groups of the Eighth Army in several of its major battles, I was impressed beyond measure by the general excellence of the work and by some remarkable series in the hands of individual surgeons. Picked series are at the bottom of most unsound surgical teaching, and it was therefore with a view to get the average results in the Western Desert, the operations done by experts under the best conditions with those done by the youngsters in the heat of the battle, the late cases with the early, the bad luck with the good, that this

enquiry was started. The figures are presented with parental pride, for the relation of a Consultant Surgeon to his Field Surgical Units is very much that of a hen to her chickens, even when, as in this case, the eggs were laid in many teaching centers throughout the Empire, and only the incubation and hatching are his.

Wounded men die from hemorrhage, shock, or infection in the first 2 hours from hemorrhage, in the first 2 days from shock of which hemorrhage is the chief cause, later from infection. Men wounded in the belly face the same dangers, but in each case there are local factors that must be considered.

Hemorrhage from mesenteric vessels or solid viscera may be very free, and there is less tendency to natural arrest than in hemorrhage from limb vessels and no chance of arrest by first aid measures such as pads, forcipressure, or the tourniquet. For these reasons, though shock may be temporarily alleviated by transfusion, it cannot be arrested or overcome, resuscitation divorced from surgery is folly.

Anaerobic infection of voluntary muscle is a remote danger in abdominal wounds unless the track passes through the buttock, and infection means peritonitis—a complication whose menace is less immediate. Torn intestines do not leak widely for many hours, and the peritoneal cavity has remarkable powers of localization and repair.

Consultant Surgeon Middle East Forces, Late Consultant Surgeon East Africa Command.

S.M.S.A., a Sudanese soldier was wounded in the right iliac fossa in the Commando raid on the Jalo Oasis in 1942. He was brought back 700 miles over desert tracks, journey 16 days during which the party languished by night and was attacked every day from the air. He drank water but ate nothing. He arrived at the River Hospital, Khar toum, on 3 September with localized incision, which was drained and cleared up rapidly leaving three intestinal fistulae which closed spontaneously. He was discharged from hospital on 7 December with his wound healed.

J.T.D.F. New Zealander was wounded in the Mameluke battle on 5 November 94 by a machine gun bullet that traversed his abdomen from side to side at the level of the umbilicus. He was admitted to M.D.S. in apparently moribund condition and transfused. He later passed through two C.C.S.s. In each unit the notes describe him as having general peritonitis and being too ill for even the slightest surgical intervention. He was given morphine and kept on intravenous blood, plasma, and fluids. On 9 November he arrived in a hospital at Alexandria (then only 30 miles from the C.C.S.). He still had general peritonitis. His abdomen was distended, tender and rigid. But in his general condition, his color, his pulse, his moist tongue and his will to live he had clearly turned the corner. His distension subsided, he started to pass flatus and later feces and he recovered without operation. He was discharged on 3 December.

It is therefore necessary at the first assessment of any abdominal casualty to decide not only whether the abdomen has been penetrated but what is wrong. Hemorrhage is a matter of first urgency; peritonitis of second urgency. A man with a belly injury seen 4 hours after wounding may be badly shocked if so he has bled, is probably still bleeding, and must be transfused then and operated on there if he is to be given his best chance. Another with a similar wound may be comparatively fit; his danger is peritonitis, and while he too needs operation, and the sooner the better he can wait another 4 hours and will be better to wait if in that time he can be brought to a more skilful surgeon, a better theater and a fairly stable unit with x rays, beds and nurses. For it cannot be emphasized too strongly that the dangers of the abdominal patient are not over when the last stitch has been put in. Recovery depends almost as much on the skill and the duration of the after-care as on the operation itself. No case travels so badly as an abdominal patient after

operation, and even a small move may be fatal, as indicated in the following paragraph taken from the Report dated 30 March, 1943 by Consultant Surgeon, 2/Λ.Z.E.F. on the Tunisian Campaign.

March 30th. Advance Party of the CCS left for new location, South of Gabes. Our CCS was emptied by an evacuation over 13 CCS close by. Twenty one cases were sent to the CCS and it was learnt later that some had died within a short period after shifting. The surgeons concerned were of the opinion that the deaths were not expected, and it appeared that even shifting ill patients few hundred yards can be very deleterious.

In comparing the mortality of different surgeons, of different units, and of different phases of the war this factor must be taken into account. Whenever the military situation has forced early evacuation the abdominal mortality has risen. Severe burns alone rival the abdominals in their inability to stand transport; limb wounds travel well after immobilization; chests after a short rest period, heads under almost all conditions.

There is great need to insist on the sober assessment of the abdominal patients for the drama of war is unfortunately a deep instinct of mankind, one which dictators can always twist to their advantage. Surgeons, and the administrative officers who control them, can hardly resist this primeval urge for the clash and thunder of conflict. If this is a battle let a be bloody might be their motto. There is no more miserable man than a young surgeon who has done his turn in a forward unit and has been relegated to the base for a spell of cold surgery, as he sits at breakfast in the comforts of Cairo reading in the morning papers of the feats of the Division with whom he has faced dust and danger; he is filled with a nostalgia that is real pain. There is no more happy man than the same surgeon working stripped to the waist in a small tent hidden by a rise of the ground from enemy guns, but well within the noise of battle. As he hears the planes going out or coming back overhead he feels he is one with those grand men he is working for; or as he lies flat for a moment while the cover of bomb fragments whines around he is happy that he is sharing their dangers. It is very difficult for such a man when he examines a soldier with an abdominal

wound, to say "Yes, he needs operation, but he is fit, and he will stand a better chance if he goes another 20 miles to X C C S." Yet that is the decision he must make, with all casualties. He must not only ask "Does he need operation?" but, "Am I the best man to do it? Is this the best time to do it? Is this the best place to do it?"

The minimum requirements of a surgical center, where abdominal wounds will be given the best chance, may be put down roughly as follows

- 1 A surgeon used to abdominal surgery. He need not be a star and he certainly should not think himself one, but he must have been well trained. Several of our best surgeons are unknown young men without higher qualifications, but they are quick, sure, neat, and fearless.

- 2 An expert anesthetist.

- 3 A theater with good light that will shine into the pelvis, a standard lamp that can give a lateral beam, and a table that can tilt. Given these requirements, a tent is as good as a building.

- 4 X-rays. Routine radiography of abdominal injuries is a waste of time, and beautiful films are not needed, but there are certain questions that can be answered only by radiography, chiefly when there is only a wound of entry and the site of the foreign body is unknown.

A single wound in the buttock without abdominal symptoms is the bullet in the pelvis or can the case be evacuated without operation?

A single wound in the chest with unilateral abdominal guarding is thus a chest wound to be left alone, or an abdominothoracic wound for operation?

A clear abdominothoracic wound should approach be by thoracotomy or laparotomy?

A single wound in the loin can the necessary surgery be done through the original wound or is laparotomy advisable?

- 5 Wards that are rainproof, dustproof, and well ventilated in spite of black out, the penthouses of forward medical units satisfy none of these requirements.

- 6 Beds, apparatus for blocking and the Fowler position, bed rests, air rings, intra-

venous drip and suction apparatus, bed pans, water bottles, and some facilities for making abdominal diets.

- 7 Skilled, but not necessarily female, nursing.

- 8 The certainty that abdominal cases can be kept for at least 10 days. Reasonable access to a good road or an aerodrome for evacuation.

Isolated surgical units and grouped operating centers must often be pushed in front of any possible site for such a set-up. They must necessarily be less lavishly equipped, less well housed, ready to move at short notice, and, therefore, less suitable for, and practiced in, the care of the seriously ill. These units should not undertake the surgery of abdominal wounds, except in those cases—nearly always of hemorrhage—in which it is clear that the man is likely to die before he reaches the unit farther back, or when they are attached to independent operational groups and there is no other surgical formation within reasonable distance behind.

This point must be insisted on, because there is the constant temptation on the part of keen medical administrative officers to push forward their surgeons beyond the point where they can do useful work, and for surgeons there to undertake more than lifesaving surgery with the splendid folly that prompted the charge of the Light Brigade.

A Field Ambulance designed and built a mobile operating theater on two captured Italian chassis. The theater, a grand example of skilful planning and clever detail, was installed in an olive orchard in Tunisia, 6 miles from the Germans, dug in and camouflaged overhead. In it a young officer was operating on a soldier with a belly wound. The man did not need operation, for the wound was parietal only, the officer was no surgeon, the unit was in any case not one to nurse an abdominal case, but it was a lovely theater. Even so, might George Washington have reasoned, "It's a lovely axe—pity not to use it?"

An operating group, consisting of a Heavy Field Ambulance reinforced by the addition of four Surgical Units, an X-Ray Unit, 40 beds, and extra nursing personnel, was working 12 miles behind the line. For some reason a single Field Surgical Unit was placed 4 miles in front of this group along an excellent road, attached to a Light Field Ambulance with only penthouse shelters and no beds. The surgeon did 10 operations including 2 abdominals, and was

then ordered elsewhere, leaving his patients to the care of the Field Ambulance.

These two instances are cited to show how things go wrong even after 3 years of fighting not from ignorance or slackness but from the reverse qualities. The hack needs the spur but the thoroughbred must be constantly held in check or he will override bounds. So in the best and most experienced surgical formations errors of overenthusiasm constantly recur unless a senior surgeon is keeping a constant watch on the ever-changing plan of the forward work in all its broad implications.

Much has been written of the surgery of abdominal wounds. My own views have been put forward repeatedly. The following points I consider decisive.

1. *Team work.* While the technique of operation has changed little since the last war except in respect of the treatment of injuries of the large intestine there has been a great improvement in the preoperative and postoperative phases. The 3 phases, preparation, operation, and after-care must be timed and co-ordinated to the needs of each case, for in none is there any room for rule of thumb. The patient must therefore be under the care of a team of which the surgeon himself is in continuous charge. Preoperation is usually under the transfusion officer postoperative care under a junior surgeon who assists at the operation but the surgeon must decide on operation and choose the time, and haunt the postoperative ward all day and all night.

The proportion of one Transfusion Unit to two Field Surgical Units has proved very satisfactory in practice. Transfusion officers are usually men with a long surgical background and well alive to the changing clinical picture of an abdominal catastrophe.

At Alamain the amount of body fluids given was 16 bottles of blood and 10 bottles of plasma to every 100 casualties. At Mareth 45 bottles of blood and 25 bottles of plasma were given to every 100 casualties.

The increase is in some measure accounted for by the high proportion of mine wounds in the later battles, but more by the realization that there is no such thing as a corpse till the funeral. As long as there is blood to pour in

and a vascular system to pour it into, a man can be kept alive and reasonably fit while his injuries are repaired if they are repairable. I have commented elsewhere on the case of a soldier who had 58 pints of blood and serum poured into him in 4 days, and who went down the line in good condition on the 10th day. Lesser amounts, none the less exceeding the total blood volume, are not infrequently put in during the course of an abdominal operation, and, provided the source of loss can be repaired, this lavish expenditure is well repaid by a useful life saved. The No. 1 Base Transfusion Unit at Cairo and later at Tripoli never failed in its task. Men were bled wherever training camps or static units provided a pool of donors, planes and refrigerator lorries brought up the blood to the army zones and the Field Transfusion Units distributed it. It is safe to say that no man whose life could have been saved by resuscitation lost it.

In resuscitating abdominal wounds it is essential to remember that the bleeding point cannot be controlled and that much of the blood given will be lost, not merely wasted, but hindering the subsequent operation by filling the abdomen and staining connective tissue planes. The blood should be run rapidly at the rate of a pint in 5 minutes, and as soon as the patient seems fit to stand an anesthetic, he should be hurried to the theater with the transfusion still running.

2. *The incision.* The incision should be the simplest possible for all wounds are infected and tend to break down afterward. The gridiron and rectus retracting incisions are disappointing in this respect, and the best are those straight through all layers in the same plane: vertical paramedian or median incisions for approach to the central part of the abdomen or the pelvis, and transverse or oblique lateral incisions for access to the lateral parts. Transverse incisions across the rectus should be avoided if possible. The Consultant Surgeon in South Africa informs me that cases with such an incision have developed large and apparently irreparable hernias.

3. *Technique.* In the abdominal surgery of warfare technique may be summed up as a simple plan, a purposeful overhaul, a rapid

repair These things are matters of character which can be supplemented but not instilled by training The forward surgeon must have good hands, a stout heart, and not too much philosophy He is called upon for decision rather than discussion, for action rather than a knowledge of what the best writers think should be done

No surgeon should start an abdominal operation without a reasoned estimate of the direction of the track and the structures involved In the abdomen as elsewhere, hemorrhage is the urgent problem, infection a secondary one If the belly is full of blood, the source of bleeding must be found and stopped, or the transfusionist and the anesthetist will not have a chance

A sucker is essential, and a footpump with valves reversed is the best type, for an electrical pump is unreliable in the heat and dust of the desert Blood in quantity suggests perforation of one of the large parietal vessels, a tear of the mesentery, or injury of one of the solid organs Arrest of hemorrhage in the mesentery is difficult, for many vessels are torn and the tissues are swollen and stained with blood Three bits of advice may be given no mass ligatures, no stitches, no catgut Mass ligatures may cut off the blood supply of loops of intestine that could have survived a more careful hemostasis, stitches start more hemorrhage than they stop, catgut is far less secure than thread and tends to slip off when the mesentery is pulled about in subsequent maneuvers

Bleeding from the spleen involves splenectomy Bleeding from the liver can be arrested only by pressure, and the pressure of living tissues is more certain than that of gauze The device of passing a few catgut sutures across the rent in the liver and tying them loosely over a fold of omentum pushed into the gap is excellent, when practicable Alternatively the omentum may be laid over the raw area and kept in contact by a gauze pack A gauze pack left in direct contact with a liver injury is liable to cause infection

Hemorrhage having been dealt with, injuries to the hollow viscera are repaired Here a definite plan, inspection of each part once and no suture till all injuries are found and

considered together is essential Holes in the small intestine cannot be felt, every part from the ileocecal junction to the jejunum must be run through the fingers and examined in rapid sequence, each injury marked and set aside Where there is one hole there are two, usually a dozen Simple suture is better than resection, in resection, single layer end-to-end anastomosis is better than side-to-side—quicker, fewer raw areas

4 *Drainage* No fast rules can be laid down as to drainage, but there is no doubt that the surgeons who drained most often saved most lives

Failure to provide adequate drainage was the cause of many of the deaths in this series

Case 261 Operation after 18 hours Splenectomy for torn spleen, abdomen closed without drainage No sulfadiazine used The patient developed paralytic ileus and died on the 13th day from a subphrenic abscess

Case 253 Ten hour case On laparotomy gross laceration of the right lobe of liver sutured No sulfadiazine No drain Died on 7th day from gross peritonitis The liver wound had healed

Case 19 Nine hour case Suture of two perforations of the jejunum, abdomen closed without drainage No sulfadiazine Gastric suction and intravenous fluids Later developed paralytic ileus Death 10 weeks after operation from suppurative peritonitis with subphrenic abscess, pelvic abscess, and abscess between stomach and spleen

5 *The exteriorization of colon injuries* A step which I have repeatedly advocated since the outbreak of war, the exteriorization of colon injuries, is, perhaps the greatest single factor in the improved results we are able to record The principle that all damaged parts of the large intestine must be excluded till the process of repair is complete applies to all injuries even suspected ones, and to all parts of the large bowel, particularly the extraperitoneal portion of the rectum The following 2 cases in this series are illustrative

Case 257 Suture of retroperitoneal tear of the descending colon, with drainage of the retroperitoneal space Sulfonamide powder intraperitoneally Later a fecal fistula developed and the patient died on the 9th day Autopsy showed the wound of the colon to be broken down over a large area, fecal matter lying free in the retroperitoneal tissues, mild general peritonitis Comment by the surgeon "Suture alone with local drainage seemed adequate, a proximal colostomy should have been done"

Case 123. G.S.W. Buttock operated upon 44 hours after injury. On laparotomy the terminal ileum and ascending colon were 'very bruised but not perforated. Retroperitoneal hematoma drained. Collapsed and died on the 5th day. At autopsy small recent perforation of the bruised ascending colon was found. Exteriorization would have saved this patient.

The method of exclusion will vary with the site and extent of the injury. A small hole on a part of the colon that can be brought to the surface will be made the apex of a loop colostomy. A larger tear in a mobile part will require resection of the damaged portion and exteriorization of the two ends as a double barrelled colostomy. An injury to a fixed portion must be repaired as well as possible, the site of repair being liberally dusted with sulfonamide powder and the retroperitoneal tissues freely drained through a separate stab. A proximal colostomy must be done at the same time.

All injuries of the rectum, however trivial, require a proximal colostomy. It is particularly important to examine carefully for these injuries in all cases of buttock wounds or of tracks involving the sacrum or coccyx. An undetected injury leads inevitably to pelvic cellulitis, a very fatal complication which a late colostomy can do little to cure. An unnecessary colostomy on the other hand is no disability. Colostomy is regarded with horror in civil life merely because it is permanent and usually the prelude to death from metastasis. In most extraperitoneal injuries the retrorectal space should be drained either through the posterior wound, or in the midline after the coccyx is removed. The anal sphincters must never be divided, but a large tube should be stitched into the anus.

Experience at the base has shown that the closure of these emergency colostomies may be a most difficult matter because the opening is often fixed in the wide scar of an infected wound and there is no proper spur. Forward surgeons are, therefore, urged when possible, to suture the limbs of the bowel together for 2 inches, and to bring them out through a separate stab at the point where the mobilized loop can be placed with least tension. A pelvic colostomy is usually the best for a rectal wound but if there is so much loss of sub-

stance that the pelvic colon may be required later for a reconstruction operation a transverse colostomy should be done.

6 *The local use of sulfonamides* While there is no doubt that drugs of this group have a powerful beneficial action in infections of the peritoneal cavity the widely held view that they are more effective when applied locally than when given by mouth or intravenously is not supported by any convincing evidence.

The only drug we have found satisfactory in the abdomen is sulfadiazine. Sulfanilamide is absorbed very rapidly, sulfapyridine and sulfathiazole tend to form cakes which may be found some days afterward at postmortem lying almost unabsorbed among coils of intestine. Sulfadiazine forms an excellent suspension in gelatine and saline which can be run in through a tube at the end of operation and diffuses in the neighborhood. Buttle has found that it remains active locally for 4 to 5 days as shown by absorption figures. Forward surgeons report that in postmortem examinations on cases in which it has been used there are remarkably few adhesions and no remaining traces of the drug. The usual practice has been to lay a rubber tube, Carrel size, close to the site of maximum soiling, and bring it out through the lower end of the incision. After closure and dressings, 10 grams of sulfadiazine suspended in 30 cubic centimeters of saline is slowly injected, followed by 30 cubic centimeters of saline alone. The tube is clamped and removed some days later.

After comparing notes with First Army surgeons, few of whom used any sulfa drugs locally I should not be prepared to assert that our results as regards infection of the peritoneal cavity were convincingly better than theirs, but I would still urge the use of sulfadiazine by the method described when supplies are available. At any rate an adequate concentration is assured at the seat of trouble in the first 48 hours, a time when the

Preparation of sulfadiazine suspension per cent solution of best sulfadiazine made in normal saline and filtered. 1. This solution added to 30 per cent of the powder and 20 per cent of the saline solution. This mixture is then per cent solution and sterilized at 15 pound pressure for 30 minutes. For use as colloidal (this is the purpose of the powder is increased to 30 per cent and the mixture is dispersed in tubes containing 15 cubic centimeters. The dose for one injection with this method is 100 grams. The tubes are then subjected at 15 pound pressure for 30 minutes.

OGHVI ABDOMINAL WOUNDS IN THE WESTERN DESERT

al route is unusable and the venous one required for many other fluids. The abdominal cavity in war has suffered far more extensive trauma to his peritoneum and his viscera by the projectile and the operation. Youth and most grilling practice but the stress and strain are in his favor but the stress and strain have been largely offset by stress and strain in battle. Complete rest of both and almost continuous intravenous fluids, and continuous intravenous fluids, and continuous intravenous fluids.

An allowance of one bed to one operation cases will cover the needs of abdominal patients in an advanced operating center. At times of rapid movement stretchers have been used and Fowler tests on the deck chair principle have been designed to fit them but these devices do not give the complete rest and comfort of a bed and a bed rest. When death is near, every detail is important.

Blood is usually being run into a vein during the operation and the drip apparatus will be taken with the patient to the ward and hung by his bed. Blood is given till the blood picture is restored and thereafter according to needs for the most part other fluids are substituted. A man who has been fighting is dehydrated and one receiving sulfonylureas must excrete freely, the standard allowance of fluids is therefore 8 pints in the 24 hours. Normal saline is given, for a while gastric suction is in action there is no need of chlorurex, 5 per cent glucose in water is usually added, and 48 hours after operation in cases that have had intraperitoneal sulfadiazine, sulfamylamide or sodium sulfathiazole are also given. One pint of plasma in the 24 hours, given as a tonic appears to have an undoubted beneficial effect, making up to some extent for the body proteins lost in the wound excretions and by the stomach tube.

Gastric suction is as essential as intravenous feeding, for ileus is almost certain, and prevention is better and far more certain than cure. The new "guys" and the wise "guys" who think they can select their cases soon learn sense, and start suction in every patient as soon as he reaches bed. Certain details may be emphasized.

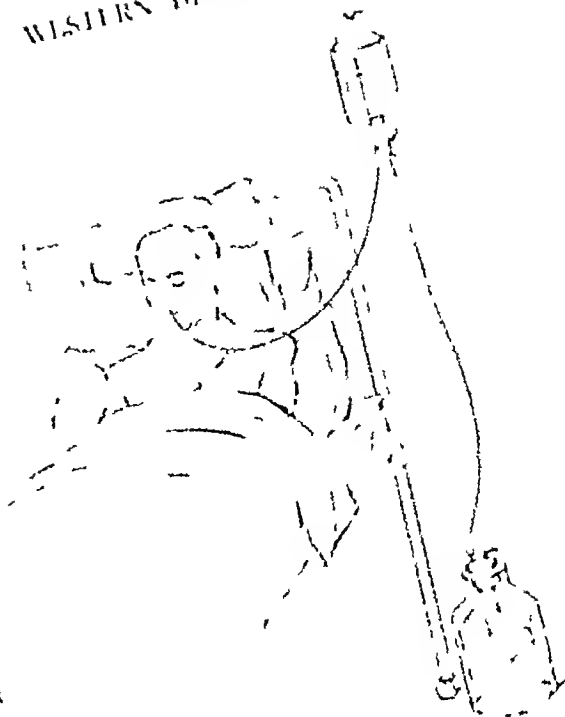


Fig. 1. Simple gastric suction apparatus using an inverted bottle for siphon.

The apparatus must be foolproof, nursing orderlies are seldom fools, but they are ordinary men with ten times as much to do as the average manager, which is much the same thing. Siphon suction, using an inverted transfusion bottle, rarely goes wrong and when it does can be put right in a minute (Fig. 1). The thing may be done 57 other ways, but they are all more complicated.

Transfusion tubing with two lateral holes is better for passing into the stomach than a Ryle tube. It is stiffer and does not block. The tube should always be pressed nasally.

It can then be returned for days without causing nausea or discomfort. While the tube is in and the suction is working the patient may drink when he feels like it. This cleans his mouth, keeps his salivary glands working, washes out his stomach, and improves his morale. Gastric suction and intravenous therapy must be continued till the danger of ileus is past, that is till continuous peristalsis is heard.

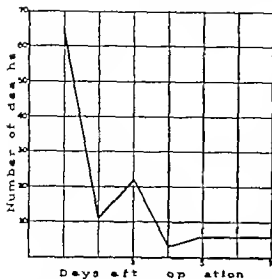


Fig. 1. Chart showing time lag between operation and death. At day 0, 64 deaths; at day 1, 34 day 2, 14 day 3, 14 day 4, 14 day 5, 14 day 6, 14 day 7, 14 day 8.

and flatus starts. Sounds that would shock a duchess are the music of the spheres to the forward surgeon. Before abandoning suction, the tube should be clamped and fluids allowed by mouth. If there is no gastric residue after 4 hours have elapsed, the tube may then be removed.

Abdominal cases must be retained in the forward operating center till they are in a state of equilibrium. In any case they should stay till their pulse, temperature, and respirations are steady till their tongue is reasonably clean, their abdominal wall moving well and flatus is being passed and till they themselves feel they have turned the corner. In most cases they should be kept till the stitches are out and the dressings are clean—an average period of 10 days.

ANALYSIS OF THE SERIES

1. Reports have been received of 381 cases in which patients were operated on for abdominal injuries received in battle between August 23 and November 23 1942 a period which included the German attack at Alem Halfa, and the Battle of Alamein. Of these 381 cases, 162 died within 4 weeks. In 8 the final result was unknown.

2. *Mortality* (a) The known mortality is thus. There were 373 operations whose result is known, with 162 deaths, or a mortality of 43.5 per cent.

b. The 8 patients about whom final reports have not been received must be regarded as almost certain survivors. They were evacuated alive from their first unit, and their deaths had not been reported to 2d Echelon 3 months later. If they are included the mortality becomes 42.5 per cent, that is 162 deaths in a total of 381 operations.

c. In 57 cases no intra abdominal injuries were found at operation. The majority of these fall into 3 groups: (1) wounds of the abdominal wall with herniation of abdominal contents, tears of the peritoneum, free blood, or extraperitoneal hemorrhage; (2) thoracic cases with rigidity or other abdominal signs—none with absent liver dullness was found to have nondevelopment of the right liver lobe; (3) buttock wounds where abdominal damage was suspected. Eight of these patients died, giving a mortality of 14 per cent. If these 57 cases are omitted, the figures are: operations on patients with injury to viscera, 324 with 154 deaths, or a mortality of 47.5 per cent.

3. *When deaths occur* The majority of patients die from the severity of their wounds, in spite of surgery.

Sixty-four or 39 per cent, of the deaths occurred on the first day.

One hundred thirty seven, or 85 per cent deaths took place before the patient was evacuated from the forward operating center.

The preponderance of deaths in the first few days is shown in Figure 2 which plots the numbers dying on each of the first 7 post operative days.

Two observations may be made in this connection: that the further forward the operating center is placed the smoother the evacuation and the better the resuscitation, the higher will be the mortality in spite of the best surgical skill and facilities; and that the mortality in the series in so far as it was known to the operating surgeons themselves, was 137 deaths in 381 cases, or 36 per cent.

4. *Factors affecting the mortality* a. *Luck*. By luck is meant the incidence of factors other than surgical skill or method that



Fig 3 A Field Surgical Unit operating tent, the type in which most abdominal surgery was done. No 5 F S U before the battle of El Alamein

affect, indeed usually determine, the result. Abdominal wounds do not form a group like gastric ulcers or goiters. The nature and size of the projectile, the viscus injured, the time lag, the surroundings, the facilities for nursing and retention, are all matters of dominant importance over which the surgeon has no control. A straightforward operation on a single perforation is doomed to failure if a bomb blows out the light and fills the abdomen with sand.

The incidence of luck appears abundantly in this series. Among the first hundred cases reported there were 27 deaths, among the last hundred, 61. In one group were 24 cases without a death, in another 21 without a recovery.

Among the poorest figures were those from a young surgeon of great courage and outstanding ability, who was constantly sited in front of the main operating groups. After 7 consecutive deaths, his first success was the following case:

Case 212. Mortar wounds (1) right arm, severing brachial artery and median nerve (2) abdomino-thoracic, entering 8th rib L, (3) L lower abdominal. Operation: Excision of wound of arm and ligature of brachial artery, laparotomy, closure of rent in diaphragm, suture of wound of stomach near fundus. Repair of four tears of small intestine, ligature of

multiple bleeding wounds in mesentery, removal of lower I B.

The patient was evacuated later to a peripheral nerve center in South Africa.

Another equally good young surgeon who worked under conditions that, for the desert, were excellent, in grouped tents near the sea and 6 miles from the Alamein line along a tarmac road, returned the following series: total abdominal operations, 56 with 17 deaths, or a mortality of 30 per cent.

His comments on the deaths are given in full, because they apply to the whole series.

"While it is obvious that each case that dies is a separate problem as regards assessment (particularly as no P M's have been done on cases subsequent to 23 Oct 42), yet a somewhat broad classification can be made of cases into 'reasonable' chances and those whose injuries are such that recovery is unlikely. Several of the latter class were done in quieter periods, when no other casualty was waiting.

"Cases not expected to recover

"A 11th v gross abd damage, or profound, prolonged shock.

"Case 1: 4 hrs, ADS moribund 3 hrs MDS, at end of which time B P finally raised to 75. During induction, curious generalised convulsion. Pupils L R 4:1. Considered probable cerebral embolus.

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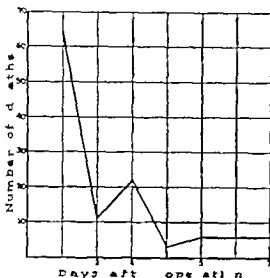


Fig. 2. Chart showing the lag between operation and death: 1st day 64 deaths, 2d day 20, 3d day 20, 4th day 5, 5th day 5, 6th day 4, 7th day 6.

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"Case 13 Nearly 1/2 small intestine in tatters. Pre op contin blood loss roughly estimated at one pint in 20 mins.



Fig. 4. An abdominal operation in progress. N. G. Field Surgical Unit, York.

Case 30. 30 h. case. Infection already well established in large wounds. 2 gas ga. given.

Case 45. With small Entry and Exit on ls, it is remarkable to find tears in the ut. mach. through which a fist. could be put, and large pieces of U. or bone in the peritoneum. This is the only case closed without an attempt to repair.

B. Cases which death was presumed to be due to 1st abdominal injury.

Case 6. Wound of legs. Amputation R. leg for rapidly spreading infective gangrene. P.M. Abd. healed and clean. L. leg bow. supp. myositis, comparable to that found in amputated on Case of death—1 trauma.

Case 6. Gross injury R. buttock and hip. Contus. haem. femoral and sup. gluteal branches. Rapid transp. ligation R. common ilia. rt. At operation small perit. abscess found. These unsuspected pre-op.

Case 9. Traumatic amput. R. leg per-trochanteric. Dis-art. hip. Bowel damage minimal. Case of death—1 trauma.

Case 31. P.M. Collapse L. lung infected haemothorax. Toxaemia from haemolysis.

Case 45. Nil in abdomen except hole in peritoneum. Rapidly devel. pneumonia. 1 CCS and death from this in 48 hrs. (verbal report).

Case 45 was one expected to recover and placed in this category only because death presumed due to chest injury.

Had this surgeon been out for statistics he would have left the first 3 alone. Had he been lucky the last 5 might not have come his way. His figures would then have been total operations, 47 with 6 deaths or a mortality of 17 per cent.

6 Time lag. An increased time lag works both ways, but chiefly toward a lower operative death rate. Delay brings peritonitis but it also eliminates the worst cases. A surgeon who receives his abdominal wounds after a week should have a mortality of under 10 per cent.

In this series the earliest time of operation was 1 hour after wounding, the latest 72 hours. The number coming to operation within 12 hours of injury was 180 with a mortality of 47.5 per cent. This mortality is higher than that for the whole series because many cases were those of severe injury kept alive only by resuscitation.

7 Time of evacuation. Three fifths of the patients die in the first 3 days after operation, but the fate of those who survive this period depends very much on whether they can be retained till they have established alimentary and circulatory equilibrium. Of the cases in this series only 81 or 2 per cent, were retained for 7 days or more. The effect of early evacuation upon mortality is shown in the following figures of 35 evacuated under a week (from information available): 17 died, a mortality of 26 per cent of 63 evacuated after 7 days, 5 died, a mortality of 8 per cent.

8 The organs involved. Table I shows the mortality of all cases with abdominal injuries limited to the stomach and intestines with or

without mesenteric damage. The series includes both complicated and uncomplicated cases.

TABLE I — ALL CASES, COMPLICATED AND UNCOMPLICATED

	Number of cases	Died	Mortality %
Small intestines	71	33	46.5
Colon	68	35	51.5
Stomach	11	6	54.5
Small intestines and colon	40	25	62.5
Small intestines and stomach	5	3	60.0
Small intestines and bladder	5	3	60.0
Small intestines and rectum	7	5	71.4

The analysis in Table I can be compared with that in Table II which shows the mortality of all cases uncomplicated by severe extra-abdominal wounds.

TABLE II — UNCOMPLICATED CASES

	Number of cases	Died	Mortality %
Small intestines	53	21	39.6
Colon	41	18	43.9
Stomach	5	2	40.0
Small intestines and colon	20	17	85.0
Small intestines and stomach	4	2	50.0
Small intestines and rectum	7	5	71.4
Small intestines, colon and stomach	2	2	100.0

For the cases operated upon within 12 hours and uncomplicated except for soft tissue injuries the mortality figures are as shown in Table III.

TABLE III

	Number of cases	Died	Mortality %
Small intestines	34	12	35.3
Colon	20	8	40.0
Stomach	2	0	0
Small intestines and colon	18	10	55.5
Small intestines and stomach	4	2	50.0
Small intestines and rectum	6	4	66.7
Small intestines, colon and stomach	2	2	100.0

5 *Frequency of injury to abdominal organs* The figures shown in Table IV, particularly those for mortality, are of little importance since few viscera except the small intestine are wounded alone. The same death may thus appear in more than one column.

6 *Treatment in detail* (a) *Preoperative transfusion* There are records of 70 patients



Fig. 5. An abdominal ward, with suction apparatus and intravenous therapy.

TABLE IV — FREQUENCY OF INJURY TO ABDOMINAL ORGANS

Viscus	Number of cases	Died	Mortality %
Small intestines	133	71	53
Colon	107	63	59
Liver	43	21	49
Rectum	23	12	52
Stomach	22	11	50
Spleen	20	11	55
Kidney	20	13	65
Bladder	12	6	50
Gall bladder	5	1	20

who were transfused before operation. Blood, plasma, and serum were the fluids used. The patients who did best and survived the dangerous 24-hour postoperative period were those who received generous amounts of blood fluids. One patient with perforation of the small intestine complicated by a SW of the right hip causing bleeding from the femoral artery, received a total of 17 pints of blood and 3 pints of serum before operation. The patient recovered. The average amount of blood fluids given preoperatively to the abdominal cases was 8 pints per patient.

b *Treatment of small intestinal injuries* The thirty-four 12-hour uncomplicated cases of small intestine injury (see 4 d above), were treated as shown in Table V. These figures, again, mean very little. Simple suture is the method preferred for all single perforations, and resection is reserved for the more serious cases.

TABLE V.—TREATMENT OF SMALL INTESTINE INJURIES

Method	Number of cases	Died	Mortality %
Suture alone	26	9	34.6
Resection	7	3	4.8
Exteriorization			

c Treatment of colon injuries The uncomplicated 12-hour cases of colon injury amounted to 20 only. They were treated as shown in Table VI. It is safe to draw conclusions from such small numbers. The total figures for injuries of the colon including multiple and complicated wounds are given in Table VII. The figures suggest that suture alone is as safe as suture with colostomy; the probable explanation is that suture was reserved for small holes without soiling of the peritoneum. It would be rash to claim that any of the colostomy patients who died could have been saved by suture alone but 2 at any rate of the 8 deaths after suture could have been avoided by cecostomy or colostomy as previously stated.

TABLE VI.—TREATMENT OF COLON INJURIES

Method	Number of cases	Died	Mortality %
Suture alone	4		
Suture and colostomy or cecostomy	5		20
Exteriorization		4	40
Resection and exteriorization			00
Resection and anastomosis			00

TABLE VII.—TOTAL FIGURES FOR INJURIES OF COLON

Method	Number of cases	Died	Mortality %
Suture alone	8	8	44
Suture and colostomy or cecostomy			45
Exteriorization	20	5	25
Resection and exteriorization		14	84
Resection and anastomosis			100
No treatment	4	4	100
Total	37	63	

d Sulfadiazine intraperitoneally Table VIII summarizes the use of sulfadiazine intraperitoneally.

TABLE VIII.—RESULTS WITH SULFADIAZINE INTRAPERITONEALLY

Number of cases treated with sulfadiazine	14
Number of deaths	
Percentage of mortality	4
Number of cases treated without sulfadiazine	7
Number of deaths	40
Percentage of mortality	43

The remaining 5 in the series of 373 traced cases had intraperitoneal sulfathiazole of these 2 died.

By taking the mortality of cases with and without sulfadiazine in a smaller series in which the time interval between wounding and operation is known, the figures shown in Table IX are obtained.

TABLE IX

Time of operation	1-4 hrs	5-8 hrs	9-12 hrs	Over 12 hrs
With sulfadiazine	45	40	31.7	30
Without sulfadiazine	45.4	5	44	75

There is thus some evidence that the use of sulfadiazine in late cases effects a reduction in the mortality.

The following 2 reports reveal the conditions of the peritoneal cavity on the 3d and 11th days respectively after operation and treatment with local sulfadiazine.

Case 4 Light bore case. 11th day perforation of the jejunum and complete division of the duodenojejunal junction. Suture and end-to-end anastomosis performed. Sulfadiazine given repeatedly in 4 hours. The patient died on the 3d day from acute pulmonary edema. He had 14,000 c. of intravenous fluids during 48 hours. At autopsy the peritoneum was "perfectly lean and the tissues were tinged with fluid."

This unfortunate outcome is a warning against the uncontrolled and unbalanced administration of intravenous fluids.

Case 337 Operation 18th hours for severe damage to the small intestine which required resection and end-to-end anastomosis. Pelvic drain and 5 gm of intraperitoneal sulfadiazine. The peritoneum was "heavily contaminated with brown contents." Eleven days after operation colostomy was performed. There "extensive plastic peritonitis" but no sign of pus.

ADDITIONAL CASES

Since the reports up to November 23, 1942 were received, records of 247 more cases have been returned by 19 different surgeons. These records are complete in all details in so far as these were known to the operating surgeon, but the final result has not in every case been checked. Of a total of 247 cases in the second series there were 84 deaths or a percentage mortality of 34.0.

The time lag from operation to death for the 84 deaths is shown in Table X.

TABLE X—TIME LAG BETWEEN OPERATION AND DEATH

	Number	Per cent
Died on table	8	10
1st day	27	32
2d day	11	13
3d day	3	4
4th day	2	2
5th day	3	4
6th day	2	2
7th day	1	1
8th day	4	4
9th day	3	4
10th day	1	1
Over 10 days	8	10
Not known	11	13

The time lag for the 247 cases in the second series is shown in Table XI

TABLE XI—TIME LAG FOR 247 CASES IN SECOND SERIES

	Total	%	Mortality %
Within 6 hours	53	24	38
Between 6 and 12 hours	76	33	32
Between 12 and 18 hours	41	18	30
Between 18 and 24 hours	21	9	48
Over 24 hours	35	16	31
Not known	19		

(Note: above percentages are based on known results)
Longest 168 hours Shortest 2 hours Average 15 hours

The frequency of injuries to the various viscera is listed in Table XII

TABLE XII—FREQUENCY OF INJURIES

	Total	% of all cases	Deaths	%
No internal abdominal injury	42	17	10	23.8
Small intestine	54	22	20	37.0
Small intestine and colon	11	5	7	63.3
Small intestine and bladder	4	2	1	25.0
Small intestine and rectum	3	1	—	0
Small intestine and liver	1	0.4	—	0
Colon	37	15	15	40.5
Colon and kidney	2	1	1	50.0
Colon and liver	1	0.4	—	0
Colon and bladder	1	0.4	—	0
Stomach	3	1	—	0
Stomach and spleen	2	1	2	100.0
Stomach and colon	1	0.4	—	0
Stomach and liver	1	0.4	1	100.0
Liver	30	12	9	33.3
Liver and spleen	1	0.4	1	100.0
Liver and kidney	1	0.4	—	0
Kidney	7	3	1	14.3
Spleen	9	4	2	22.2
Rectum	10	8	3	16.0
Rectum and Bladder	2	1	2	100.0
Bladder	5	2	1	20.0
More than two organs involved	7	3	5	71.3
Not known died on table	3	1	3	100.0
	247	100	84	

Sulfadiazine The number of patients treated with sulfadiazine was 98 with a mor-

taity of 26.5 per cent, the number of patients treated without sulfadiazine was 149, with a mortality of 39 per cent

Combining the figures for the 2 series, we have a total number of cases of 628 with total deaths of 246 or a percentage mortality of 39.2

COMPARISON WITH THE FIGURES OF THE LAST WAR

Ἡμεῖς τοὶ πατέρων μεγ' ἄμεινονες εὐχομεθ εἶναι
(Homer's *Iliad*, Book IV, verse 405)¹

In absence of works of reference it has only been possible to trace the figures quoted from Cuthbert Wallace "War Surgery of the Abdomen" given in Hamilton Bailey's *Surgery of Modern Warfare* Table XIII giving the mortality of wounds of the small intestine alone or in combination, is from this work

TABLE XIII—WOUND OF SMALL INTESTINE (From Hamilton Bailey, *Surgery of Modern Warfare*)

Site of wound	Last War	Total Middle East	Last War	Mortality Middle East
Small intestine	255	71	65	9 46 5
Small intestine and stomach	14	5	7	1 60
Small intestine and colon	85	40	74	62 5
Small intestine and rectum	4	7	100	71 4
Small intestine, stomach and rectum	5	2	100	100
Small intestine and bladder	16	5	92	7 60

In comparing this series with any in the last war, it must be pointed out that the conditions of operating in the Western Desert were at most times far worse than in a C C S in France, and that many more severe cases were tackled than ever reached the operating theater in 1918. Then many men died at Field Ambulances, and of those reaching a C C S 20 per cent were regarded as moribund and unfit for operation. Even in the comparatively mild group of injuries limited to the alimentary canal, it is noteworthy that in the Middle East series 45.4 per cent of the wounds involved structures other than the small intestine in the last war series only 32.8 per cent. Men like John Fraser, Gordon

¹We never claim to be far better than our fathers (Translated by Professor E. L. Highberger Northwestern University College of Liberal Arts Department of Classical Languages)

Taylor Charles and Lockwood lacked nothing in courage but they lacked the transfusion service of Middle East that has always supplied the fighting forces with blood in abundance and with the apparatus and skill to administer it. Every man that could be resuscitated was resuscitated and every man that could be brought to the table alive was tackled unless there was another with a better chance in urgent need of surgery at the same time. Among these were many hopeless cases, such as the one who is stated to have been losing blood at the rate of a pint in 30 minutes. It is probably true to say that two thirds of the men who died in the first 24 hours (i.e. 42) would have been excluded from 1918 statistics.

A further point of difference is that 98 per cent of these patients were traced to the base whereas in the figures of the last war most of the statistics deal with survivals in the forward units only. On such a reckoning 25 of the deaths in this series would have been recorded as survivals.

If then these deaths are subtracted from the total we get the following for comparison with the results of the last war

Total cases	1724	131
Total mortality	62-67	
Percentage mortality		7

CONCLUSION

In conclusion I would repeat that this is the work of the surgeons of Eighth Army. Among them were Australians, New Zealanders, Canadians, Americans, Frenchmen, Greeks, and Slavs. But the majority were from the United Kingdom the surgeons of the C.C.Ss. and Field Surgical Units of the Middle East Forces. Of them I have written in a report to the War Office —

"They're a wonderful group. They have shown the effect of the organization of forward surgery and by their presence and through their efforts the wounded soldier of the Eighth Army has been better looked after than any other fighting man in the history of war."

EXPOSURE OF THE RECURRENT LARYNGEAL NERVES IN THYROID OPERATIONS

Further Experiences

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THE recurrent laryngeal nerves are extremely important and valuable because of their intimate anatomic relationship to the thyroid gland. No operation upon the thyroid gland, no matter how trivial, can be done without endangering their conductivity.

In 1938 I advocated routine exposure of the recurrent laryngeal nerves during thyroid operations as an anatomic approach to their preservation and reported a series of over 3,000 thyroid operations in which this had been done.¹ By this method the incidence of nerve injury has been greatly lessened, now being less than 0.3 of 1 per cent, and this figure includes operations performed for cancer of the thyroid.

Since the original series of cases was reported, the nerves have been exposed in practically every thyroid patient operated upon by a member of the Lahey Clinic staff. I, very general surgeon, quickly learned the procedure, and even in the patients who have had 3, 4, and occasionally 5 subtotal thyroidectomies before coming to us for further thyroid removal, the nerves have been demonstrated if the cords were functioning normally. Even in deep intrathoracic goiters extending nearly to the diaphragm and in most of the carcinomas of the thyroid, particularly if removable, the nerves have been demonstrated. Even if the nerves have been cut previously, demonstration of the proximal segment of the cut nerve is usually possible.

Whenever a surgeon makes the statement that exposure of the recurrent laryngeal nerves in thyroid surgery is unnecessary, I believe that he should be able also to state his incidence of nerve injury after thyroid operations, his incidence of tetany, and his incidence of

persisting hyperthyroidism. These three complications are influenced directly by exposure or nonexposure of the recurrent laryngeal nerves. Demonstration of the nerves adds little to the operation and causes no cord dysfunction.

It would be as sensible in performing total hysterectomy to try to avoid injury to the ureters by staying away from their usual location as it would be to try to avoid injury to the recurrent laryngeal nerves by keeping clear of their usual, but sometimes abnormal, location. This sound surgical principle prompted me when performing thyroid operations to expose the recurrent nerves in order to ascertain their position and thus to preserve them. The avoidance of operative injury to the recurrent laryngeal nerves by leaving them covered with an apparently safe amount of thyroid tissue would seem to be a tradition from the Kocher era of thyroid surgery of a number of years ago. No disrespect is intended to the father of goiter surgery, to whom we owe so much, as a result of this worshipful attitude, however, the recurrent laryngeal nerves have come to be regarded as almost untouchable. The impression has been that exposure and handling of the recurrent nerves would result in temporary, if not permanent, voice changes and cord damage.

After at least 10,000 recurrent laryngeal nerve dissections at the clinic, the statement can be made with added certainty that, contrary to the prevalent opinion, the recurrent laryngeal nerve withstands dissection, handling, benign tumor pressure, and even at times inclusion in a malignant growth without alteration in its ability to conduct the impulses that produce the necessary position changes in the cords for speech and breathing.

The recurrent laryngeal nerve is particularly interesting and unusual; it is composed

¹From the Department of Surgery, The Lahey Clinic
Lahey, J. H. Surg. Gyn. Obst. 1938, 66:775-777.



FIG. a, Normal glottic space. b, Bilateral abductor paralysis soon after injury to the nerves. The patient can breathe but cannot talk. c, Bilateral abductor paralysis after the cords have fused together. The patient can talk but cannot breathe on exertion.

of two sets of fibers carrying impulses which produce opposing muscle actions—adduction and abduction and in addition carrying co-ordinated impulses concerned with speech and breathing. The nerve is so closely related to respiration that any interference with its function eventually interferes materially with breathing. Lest this statement suggest that many nerve injuries have occurred at the Lahey Clinic I wish to add that in 22,700 thyroid operations there has been no permanent bilateral injury to the recurrent nerves.

Those inexperienced with injuries to the recurrent laryngeal nerves, dread most the effect of the injury upon the voice. What could be worse than to be responsible for complete and permanent loss of voice! Those who have dealt with many injuries to the recurrent laryngeal nerves (as we have from having them referred to us) fear the loss of voice less than the ultimate interference with breathing which is due to inability to abduct the vocal cords and to the essential narrowing of the glottic space as atrophy fibrosis and fixation of the arytenoid muscles gradually shorten the immobile cords and bring them closer and closer together in the midline (Fig. 1 c).

UNILATERAL INJURY

Injury to one recurrent laryngeal nerve rarely causes much interference with breathing since the innervated remaining cord usually can be abducted sufficiently to provide an adequate glottic space as an airway. Reasonably adequate glottic space is present for breathing provided the breathing is not too vigorous and the demand for oxygen is not greatly increased. When the breathing effort

is exaggerated as in emotional or physical activity an audible stridor frequently is heard. This stridor is the result of an unusual amount of air being sucked rapidly through an aperture incapable of adequate compensatory enlargement and with a paralyzed cord fixed in the center of the airway.

While marked temporary change in voice often results this usually is largely overcome by compensation; the remaining cord overapproximating itself to the paralyzed cord as it is contracted by fibrosis and is fixed in the midline. While this compensation eventually produces a satisfactory voice the unilateral nerve injury and eventual cord fixation result in permanent voice or breathing deficiency. With one cord paralyzed the voice usually lacks its previous range and is incapable of the tones necessary in vigorous effort such as shouting or even moderately loud singing.

Unilateral recurrent nerve injury frequently has so little immediate postoperative effect that it fails to attract the attention of the patient or the surgeon. Even long after the injury when the single paralyzed cord has contracted and become fixed in its permanent median position the only inconvenience may be cracking of the voice on forceful use. Later when the paralyzed cord becomes fibrosed and fixed there may be considerable stridor on effort and at times difficulty in obtaining sufficient air because of the lesser caliber of the airway.

BILATERAL INJURY

Injury to both recurrent laryngeal nerves, resulting in loss of innervation of both vocal cords with the inability to abduct or adduct the cord is a real surgical calamity not so much

because of its effect upon speech but because of its ultimate effect upon breathing and even usually its limitation of physical effort. Many misunderstandings and misconceptions about bilateral recurrent laryngeal nerve paralysis exist. Even though the principles involved and the symptoms present have long been well known if the surgeon or laryngologist does not deal with these conditions in numbers he frequently fails to understand the course of events following injury of both laryngeal nerves (Fig. 1, a, b, and c).

When both nerves are injured, the cords are lax and cannot be tensed, adducted, or abducted. At first this results in any great difficulty in breathing, but the loss of voice is alarming to both the patient and the surgeon. Usually within 3, 4, or 5 months however the voice begins to return. As the result of atrophy, fibrosis, the laxity of the cords has been taken up so that a voice is produced. Within a few weeks the voice becomes even more improved as the cords by fibrosis and fixation progressively approach each other (Fig. 1, c).

At about this time the patient begins to have difficulty in breathing, particularly on any unusual effort. The reason for this is that the fibrotic contraction causes the cords further to approach the midline and the glottic space is narrowed until it eventually becomes, when viewed through the laryngoscope, a mere slit (Fig. 1, c). On any unusual effort the characteristic crowing sound will result as the large amount of air vibrates the cords while passing through this narrow glottic space. The air intake under effort is so small that immediate limitation of effort is necessary to avoid the alarming and disturbing effect of inadequate oxygenation. If the patient hurries upstairs the sense of suffocation may be so pronounced that he must walk very slowly or even sit down.

I frequently have compared the patient with bilateral abductor paralysis with a windbroken horse or what is known by horsemen as a roarer. The history of a well known race horse, a winner of the Kentucky derby but a few years ago, illustrates this phenomenon. As this horse participated in races, reports were made by observers on the back stretch

and on the turns of race tracks that his breathing was becoming more and more audible. Soon he was retired as a roarer. A roarer or windbroken horse has toxic paralysis of the recurrent laryngeal nerves, just as a human being with Bell's palsy has a toxic paralysis of the facial nerve. The difference is that muscle function and nerve conduction in the horse with toxic bilateral paralysis do not return as they usually do in human beings with Bell's palsy.

Probable recurrent laryngeal paralysis can be demonstrated without inspection of the cords by asking the patient to count to the highest possible number without taking a breath. Upon reaching this number he immediately will take a large breath because of oxygen want, and very audible inspiratory stridor will result from the effort to obtain a large amount of air through an inadequate glottic space.

While this demonstration of recurrent laryngeal nerve injury is of clinical interest, injury can be determined positively by a direct laryngoscopic examination. With operative exposure of the nerve this inspection is unnecessary since the surgeon can guard against injury. If the nerves are not exposed and protected, the cords certainly should be examined postoperatively by direct laryngoscopy. If paralysis exists the nerves should be exposed surgically. If severed they should be resutured, and if included in a tie the tie should be freed and the nerves restored to their position. Never again will there be an opportunity comparable with that at the time of operation to do a satisfactory suture of the nerves and possibly to restore function.

ANATOMIC VARIATIONS

The major anatomic variations observed at the Lahey Clinic are related chiefly to whether the recurrent laryngeal nerve descends into the thorax (Figs. 2 and 3).

Since the anatomic position of the non-anomalously located recurrent laryngeal nerve is related so consistently to the inferior thyroid artery, demonstration of the nerve necessitates demonstrating a considerable portion of the inferior thyroid artery from its point of emergence from behind the common carotid

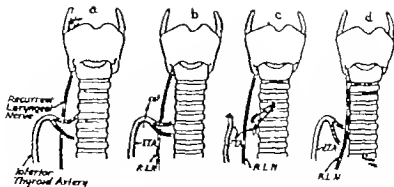


Fig. 2. a, Nerve passing over the inferior thyroid artery. b, Nerve passing under the inferior thyroid artery. c, Method of dividing the inferior thyroid artery to follow nerve up to its point of entrance into the larynx. d, Position of nerve when it is pushed against the trachea by an intrathoracic goiter or by an adenoma.

artery to its division to enter the body of the thyroid gland.

If the nerve passes over the artery (Fig. 2a) it will be demonstrated as the trunk of the artery is dissected. If the thyroid gland is elevated out of its bed the nerve will also be lifted as the inferior artery is lifted upward too and will be in much greater danger of surgical injury than is the nerve which passes behind the artery.

If the nerve is in its most common position beneath the inferior thyroid artery (Fig. 2b) a search beneath the inferior thyroid artery and between it and the trachea will be necessary. Even though the thyroid gland is lifted out of its bed it still remains unmoved in a relatively safe position behind the artery. If the nerve does not appear immediately when this area beneath the artery is separated gently with blunt scissors, it usually can be palpated readily when the finger is inserted in the region beneath the inferior thyroid artery and the tissues pushed against the rigid tracheal wall.

Contrary to the usual impression the recurrent laryngeal nerve is of considerable thickness and is frequently enough on stretch so that it can be palpated as a cord passing obliquely from without inward and upward to its position beneath the inferior thyroid artery. Because of its occasional laxity it sometimes can be pushed against the trachea and palpated as a cordlike structure. With good light and exposure a dry field and re-

traction of the common carotid artery well outward the longitudinal fibers of the recurrent laryngeal nerve can be demonstrated quickly and easily. Even when scarring by previous operation exists the nerve can be demonstrated satisfactorily. However if the nerve cannot be followed upward with complete satisfaction as to its position, the inferior thyroid artery can be divided (Fig. 2c), the cut ends tied, the inner section lifted upward, and the course of the nerve demonstrated to the point where it penetrates the larynx to become intralaryngeal in position.

In exophthalmic goiter the nerve usually passes from a fairly external position as it emerges from the thorax obliquely upward and inward from beneath the common carotid artery under or over the inferior thyroid artery to the point where it enters the larynx. When however there is an intrathoracic goiter or an adenoma of the thyroid, particularly arising from the body or lower pole of the thyroid and imbedded in a position beside the larynx, the nerve is pushed and flattened against the trachea (Fig. 2d). This is particularly true in deep intrathoracic goiter. As soon as the adenoma is lifted up or the intrathoracic goiter is delivered the recurrent laryngeal nerve is plainly visible as a white cord adherent to and running straight up the side of the trachea.

Having in mind the anomalous recurrent laryngeal nerves which every surgeon operating on many thyroid glands has encountered

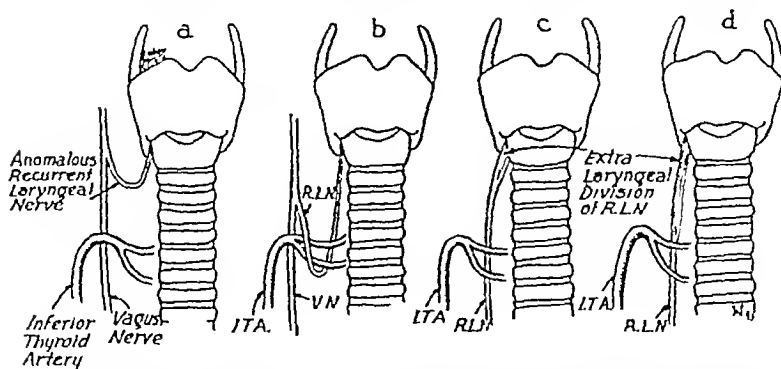


Fig 3 a, Anomalous nerve passing straight from the vagus nerve into the larynx b, Anomalous nerve passing down under the inferior thyroid artery and then up into the larynx c, Extralaryngeal division of the nerve into abductor and adductor fibers d, Same as c with lower separation

it is important first to demonstrate that the nerve is in its normal position. If it is not found in its normal position, a search should be made at the upper pole of the thyroid gland to rule out the nondescending anomalous type of recurrent laryngeal nerve. Unless one is aware of the occasional existence of such an anomalous nerve passing directly from the vagus nerve to the larynx, it could be injured when the superior thyroid artery is tied (Fig 3, a). Similar nondescending recurrent laryngeal nerves are seen occasionally (Fig 3, b), in which the nerve descends to the level of the inferior thyroid artery.

In addition to these nondescending anatomic variations of the recurrent laryngeal nerve, occasional variations are found in the nature of extralaryngeal division of the nerve into its adductor and abductor fibers (Fig 3, c and d). Most recurrent laryngeal nerves enter the larynx undivided. A few, however, divide just before entering the larynx and possess two distinct sets of fibers (Fig 3, c). Still less frequently, this division occurs at a lower level, at or below the point where the recurrent laryngeal nerve crosses under or over the inferior thyroid artery (Fig 3, d). It is extremely important for all surgeons to be aware of the occasional existence of this extralaryngeal division lest injury to the individual set of fibers of either group results in specific paralysis of the adductor or abductor muscle without influencing the opposing muscle.

DEMONSTRATION OF NERVES

The three most essential principles of satisfactory demonstration of the recurrent laryngeal nerves are adequate exposure, a dry field and a good light.

Adequate exposure involves cutting across the prethyroid muscle, and in practically all our cases the prethyroid muscles are severed high. There is no resulting atrophy or interference with function, and certainly there is better exposure. The thyroid gland must be lifted out of its bed with double hooks (Fig 4). Dissection of the internal jugular artery from the thyroid gland must be carried out, as well as of the area filled with areolar tissue between the trachea and esophagus. The common carotid artery must be freed so that the inferior thyroid artery can be cleared at its

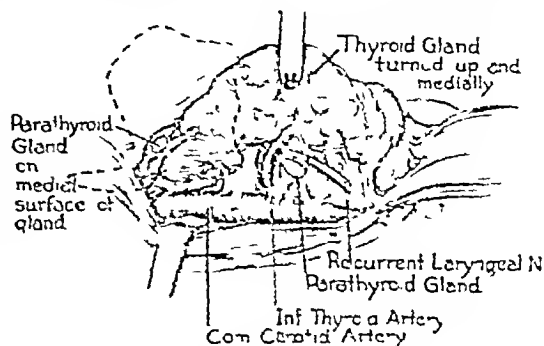


Fig 4 The thyroid gland has been turned up for partial thyroidectomy (right lateral view of gland). The relationship of the recurrent laryngeal nerve to the inferior thyroid artery and inferior parathyroid gland is shown.

point of emergence from behind the common carotid artery and so that it can be dissected throughout its complete course up to the gland.

All small bleeding veins must be snapped and ligated in order to maintain the dryness of the field. Otherwise the areolar tissue between the carotid artery under and back of the gland will be filled with hematomas, stained with blood and anatomic color relations will be so disturbed that the dissection will be much more difficult.

PREVENTION PREFERABLE TO RESTORATION

Four patients in whom both recurrent laryngeal nerves had been cut have been referred to the Lahey Clinic, but unfortunately in each case several months had elapsed since the subtotal thyroidectomy at which the nerves were cut. Finding and suturing the nerves was not extremely difficult; however the arytenoid muscles were fixed and the cords and arytenoid muscles were so fibrosed that even if conductivity of the nerves had been restored abduction and adduction would not have occurred. To appreciate the effect on the vocal cord of cutting the recurrent laryngeal nerve one has only to compare the full appearance of the functioning cord with the pale, thin, sharp edged appearance of the paralyzed and atrophied cord. I am convinced that the best management of recurrent laryngeal nerve injuries is of a preventive character.

The features which militate against good results in the repair of cut recurrent laryngeal nerves are that when one makes an early search for the cut nerves when the chances for

restoration of function are the best, before the cords are atrophied and the arytenoid muscles are fixed the field is still filled with edema and becomes bloodshot and oozes upon the slightest manipulation.

If I personally had a patient who after operation showed immobile vocal cords, I would wait a week to 10 days to see whether cord motion would return. If not and if the patient's condition warranted it I would in spite of unfavorable wound conditions, reopen the neck and endeavor to find and suture the cut or injured recurrent nerves.

SUMMARY AND CONCLUSIONS

The following points are discussed: (1) The relationship of the recurrent laryngeal nerves to speech and breathing; (2) the course of events with regard to speech and breathing difficulties after injury to recurrent laryngeal nerves; (3) the anatomic variations in recurrent laryngeal nerves; (4) the methods of demonstrating and preserving the recurrent laryngeal nerves; and (5) the reasons why secondary suture of cut or injured recurrent laryngeal nerves is unsatisfactory.

In conclusion I would state that without preservation of the recurrent laryngeal nerves by actual exposure in thyroid operations, one can only hope that they have been saved. Postoperative suture of injured or cut recurrent laryngeal nerves, even a few months after the thyroidectomy is unsatisfactory. If this could be done within 2 to 3 weeks of the time of the injury the results might be more satisfactory. The best approach to the problem of severed or injured recurrent laryngeal nerves is prevention and not restoration.

THE DETERMINATION AND TREATMENT OF PRESSURE CAVITIES IN PULMONARY TUBERCULOSIS

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THE essential danger of tuberculous cavities in pulmonary tuberculosis has long been recognized. Modern collapse therapy, which has artificial pneumothorax as its starting point, attempts to place the diseased lung at rest and aims at closure of pulmonary cavities. The importance of cavity closure as a prerequisite to successful treatment of pulmonary tuberculosis is accepted by the majority of phthisiologists. Unfortunately, however, tuberculous pulmonary cavities are not easily closed and artificial pneumothorax, which at first was hailed as a solution to the problem, in spite of many brilliant results, failed to close a large number of cavities and led to attempted closure of these cavities by extrapleural and intrapleural pneumonolysis. In quick succession various other methods of surgical collapse were developed, each one being designed to promote cavity closure when pneumothorax had failed, thus, thoracoplasty, phrenic nerve interruption, Semb apicolysis, extrapleural plombage, extrapleural pneumothorax, and other procedures have been employed with gratifying results. Excellent as have been the results of thoracoplasty, there is still a large group of cases in which the cavities have not closed, such cavities (residual cavities), although reduced in size, have remained open in spite of the most extensive surgical collapse. The residual cavity and the original giant cavity, too large for collapse therapy, presented unusual difficulty in treatment and served as a stimulus for investigation of cavity formation and closure.

The authors have, for some years, been occupied with this problem and were convinced that there must be a way of predetermining which cavities could be closed by thoracoplasty and which would remain open as residual cavities. The statements of Coryllos that certain cavities ("tension cavities") were inflated by increased intracavitary pressure due to a bronchial check valve influenced us to needle a residual cavity

during a revision thoracoplasty operation. Much to the surprise of all, the intracavitary pressures were very high. It was quite evident from the manometric fluctuations that the bronchus entering this residual cavity was partially blocked. It immediately occurred to us that perhaps this residual cavity had been a "tension cavity" which had been displaced to the hilar region by many stages of thoracoplasty. Thus, if the contention of Coryllos that cavity closure depended upon the patency of the cavity draining bronchus were true, then a study of intracavitary pressures before an attempt at thoracoplasty collapse should yield information concerning the state of the cavity draining bronchus. The needling of tuberculous cavities had been done before and was not unattended by serious complications. We therefore set about developing a safe technique for the needling of large apical cavities, for which we found it necessary to design a new set of instruments. Convinced as we were that many residual cavities were "tension cavities" prior to thoracoplasty, we were unable to accept the principle of extensive extrapleural collapse applied to cavities in which the cause of their maintenance was probably within the draining bronchus. Direct drainage of such cavities to relieve the tension seemed a logical method of obtaining their collapse. A perusal of the literature disclosed conflicting reports as to the efficiency of cavity drainage in large cavities. Most workers applied intracavitary suction drainage to any large cavity without differentiation. All reports indicated that this procedure also was not without fatal mishaps. To avoid fatal complications we have worked out a new technique of transthoracic intracavitary drainage which requires the use of special instruments in addition to those devised for cavity needling. The instruments which are used have been designed by the authors and they have up to the present time proved to be most satisfactory.

We believe that there is a rational and logical basis for the treatment of tuberculous cavities in which all methods, having a sound physiological and anatomical background, may be of use and in which no one theory or procedure can be uni-

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This contribution was awarded the Casgrain Charbonneau Prize 1942 by the Faculty of Medicine, McGill University.

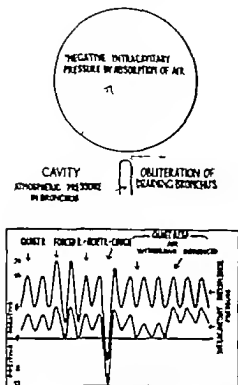


Fig. Cavity with completely obstructed bronchus. Intracavity pressures fluctuate with inspiration and expiration and synchronous with variations of intrapleural pressure. Note: The cavity does not change in size except slowly by air absorption.

verbally applied. The objective should be, not only to arrest active disease with closure of cavities, but to do so with the least possible damage to healthy lung parenchyma. Too often large cavities are closed by multiple stage intracavitary procedures, the disease is arrested and the patient becomes respiratory cripple, useless to himself and to his community. It is thus apparent that a more efficient and less destructive method of collapsing cavities is desirable. Such a method seems to be on hand in the form of transthoracic cavity drainage. By the use of this method tuberculous pulmonary cavities can be reduced in size and in certain cases completely closed. The process of cavity closure takes place in such a manner as to collapse only the diseased areas and preserves the surrounding healthy lung parenchyma. As a matter of fact there are some workers who make the claim that cavity closure by transthoracic cavity drainage actually results in an increased vital capacity.

HISTORY OF TRANSTHORACIC CAVITY DRAINAGE

Over a period of many centuries there have been isolated records of direct cavity drainage carried out with or without packing of the cavity. In fact, transpleural opening of pulmonary cavities dates back to the time of Hippocrates. Baglivi 1696, was of the opinion that opening of cavities leads to cicatrization; a similar opinion was held by Barry (4, 5) 1763. The surgeons of this period were apparently well aware of the danger of transpleural opening of pulmonary cavities in the presence of a free pleural space. Sharpe, 1769, drew attention to the importance of pleural symphysis in transthoracic opening of cavities. It was felt at that time that the good influence resulting from transthoracic opening of pulmonary tuberculous cavities was due to better drainage and stopping of hemorrhage and that possibly there was a kind of "disinfection." Nearly three quarters of a century later in 1845, Hastings and Stokes attempted to cure a large apical cavity without section, by introducing a rubber catheter through the chest wall directly into the cavity. The catheter was left *in situ* for 2 months with marked improvement in the patient's clinical condition. In 1855, De Cereville expressed the belief that cavity drainage had a promising future and similar reports are to be found in the writings of Sauerbruch, Gerkler Nissen, Sonnenberg, Tüfker and Runenberg. Attempts were made to treat large tuberculous pulmonary cavities in a manner similar to abscesses elsewhere in the body. The mortality was high, as was the morbidity and there resulted, in most cases, a bronchocutaneous fistula. In many instances, however the cavity became sterile for tubercle bacilli and shrunk down to a small fistulous tract. Such was the experience of Lovelace, 1922, and Rankin and Weid, 1924. Lovelace opened into three large cavities by resection of a portion of the chest and cavity wall his object being to sterilize the cavity wall with methylene blue and gentian violet. The cavities quickly became sterile for tubercle bacilli, a phenomenon which the authors attributed to the action of the dye. The progressive shrinking in size of the cavity until now it is little more than a sinus leading into the chest wall and through the lung was unexplained and unexpected. In spite of improved surgical technique and acquired knowledge gleaned from drainage of nonspecific lung abscesses, the results of direct cavity drainage in pulmonary tuberculosis continued to be poor. Direct cavity drainage as a method of treating tuberculous pulmonary cavities remained in the background and was somewhat in disrepute. Revival of interest in this type of treatment

veloped as a result of new ideas concerning the method of cavity formation and cavity closure

It would seem that the modern concept of cavity mechanics had its birth in 1922 when Hall first drew attention to the condition of the bronchus draining a cavity. He described a "semi-detached" piece of lung blocking the bronchus, permitting air to enter but for the time being not allowing any to "escape", the arrangement, he felt, was the cause of ballooning out of the cavity. Mechanical factors in cavity formation which had previously been overlooked soon came to the fore and helped to explain the rapid formation and disappearance of certain cavities. Reinders, 1928, stated that the volume of the cavity does not represent the amount of lung tissue actually destroyed but largely lung which has collapsed and which is still capable of expansion. He compares a small defect in the lung to a slit in a tense elastic membrane which becomes a circular hole, stretching of the membrane enlarges the hole much more than the membrane. Pearson, 1930, needed a large cavity through the chest wall and found the pressure readings to be above atmospheric, after withdrawing approximately 750 cubic centimeters of air the pressures remained on the positive side. He considered that many cavities are due to inflation. Brooke, 1931, likewise needed a large cavity and found that the pressures were above atmospheric, to which they returned after the withdrawal of air. He considered that he was dealing with a valvelike obstruction of the bronchus leading into the cavity. Thus slowly over a period of a few years it has been shown that certain cavities are in communication with a partially obstructed bronchus and exhibit increased intracavitary pressures. As Korol, 1935, so ably expressed it, the "cause of sudden changes in the size of a tuberculous cavity is to be looked for in the state of the draining bronchus. A temporary narrowing of the bronchial channel may cause a ball valve mechanism with expiratory obstruction and rapid enlargement of the cavity. Relief of the obstruction leads to contraction of the cavity." The mechanics of tuberculous pulmonary cavities still needed much clarification. In the year 1936, Coryllos (9), in a brilliant manner proved through gas analysis of aspirated intracavitary air the degree of patency of the draining bronchus. He showed that, in a cavity with an open bronchus, the pressures were atmospheric and the oxygen in the cavity was high (16 to 19%), whereas the carbon dioxide was extremely low (1% or less). In cavities where there was a check valve mechanism, permitting air to enter the cavity more freely than it could go out, the pressures were on

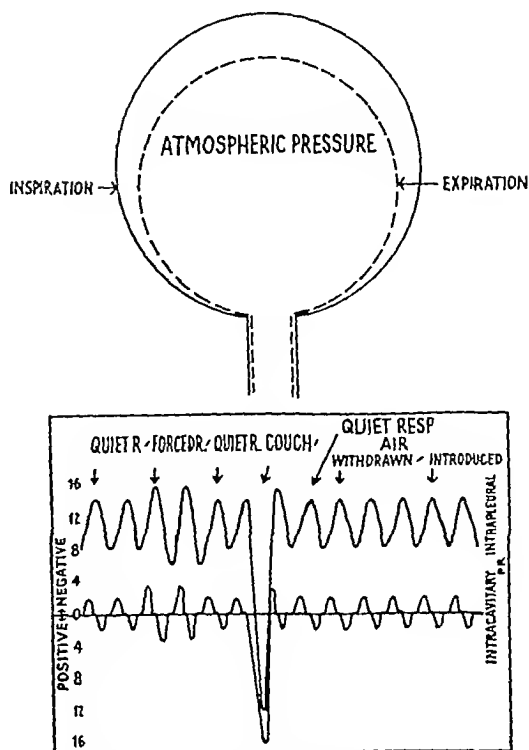


Fig 2 Cavity with completely patent bronchus. The cavity wall expands and contracts with inspiration and expiration respectively. There is a free exchange of air between cavity and bronchus. The intracavitary pressure does not synchronize with the intrapleural and one tends to return to zero before completion of each respiratory phase. Maximum and minimum of intracavitary pressures advance those of the pleura. This time interval and the amplitude of intracavitary oscillations are related to the size of the entering bronchus.

the positive side and oxygen was less (10 to 17%), whereas the carbon dioxide content had increased (2 to 3%). If the bronchi were closed, especially following thoracoplasty, the intracavity pressures were negative and the oxygen content was below 1 per cent, whereas the carbon dioxide content had risen to levels of 5 per cent or higher. He considered that there were three main types of cavity: (1) in which the bronchus was open permitting a good growth of tubercle bacilli with a positive sputum, (2) in which the bronchus was closed and the sputum disappearing, the gas entrapped slowly absorbing with resultant shrinking and eventual closure of the cavity, (3) narrowing of the bronchial lumen resulting in a check valve type of mechanism, increased intracavitary pressures and a concomitant ballooning out of the cavity. In a subsequent article Coryllos (10),

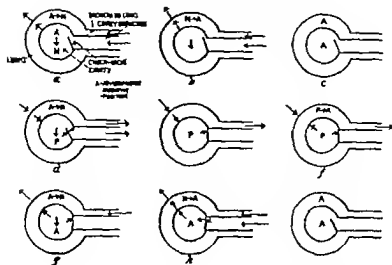


Fig. 3a.

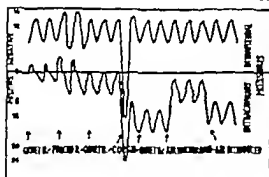


Fig. 3b.

Figs. 3a, 3b, above, and b. Cavity with intermittently closed bronchus. The arrows indicate the direction of flow or pressure during inspiration and expiration. The intracavitary pressure is dependent on the efficiency of the check valve. In certain stages of the respiratory phase the bronchial check valve closes so that the lower cavity pressure parallel those of the pleura. Suddenly during inspiration, pleural may be reached at which the check valve opens so that the pressure temporarily behaves as to cavity with completely patent bronchus. As result of this mechanism air is trapped with each respiratory phase. This results in increased intracavitary pressure with resultant progressively ballooning out of the cavity wall. Changes in cavity size are not considered in Figure 3a. and b. Inspiration, c, end of inspiration phase, d, beginning of expiration phase, e, expiration, f, end of expiratory phase, g, beginning of inspiration phase, h, inspiration, i, end of inspiratory phase.

1938, stated that "complete closure of the bronchi is the only mechanism by which tuberculous cavities may heal, whatever their size and the nature of their walls may be, even when anatomically they cannot collapse." The views of Coryllos were severely criticized and opposed at first by a considerable number of authors. However as time went on and knowledge increased, evidence from many quarters was published corroborating the concept of Coryllos.

Eloesser, 1917 apparently inspired by the work of Coryllos, states the relation of pulmonary cavities to the bronchial tree is important, not only theoretically but clinically. Furthermore, a partially or intermittently blocked bronchus can keep a cavity initiated and prevent its cure. He suggests that "while the cavity may open, a previously occluded bronchus may become a stop-valve mechanism." Eloesser applied the term

blocked cavity to such cavities. He attempted to drain the cavity in 3 cases by introducing catheter directly into the cavity through the chest wall and applying suction. Unfortunately suction was applied for 16 days only in 1 case and then discontinued. In a second case it was continued for a period of 5 months without effect and in the third case suction was applied to a large cavity in a desperately ill patient who died 55 days after the institution of suction drainage. Eloesser concluded that "closed suction drainage of blocked cavities, a method which at the outset seemed most promising and reasonable, has been failure." There was another group of workers who believed as Coryllos did, namely that cavities with a partially occluded bronchus would tend to grow due to increase in the cavity pressure, whereas complete closure of the draining cavity bronchus would lead to the closure of

the cavity Thus at the Forlanini Institute, Bottari, on August 8, 1938, using the instrument devised by himself and Monaldi, inserted a catheter into a cavity Continuous suction drainage was used with such good effect that intracavitary suction drainage was applied to many cases The Monaldi (20-24) procedure as it is known has been used in many European and North and South American clinics Following the first publication of Monaldi and his associates there have been a considerable number of reports by different workers with regard to the efficacy of this new collapse procedure These, along with Monaldi's own results will be examined more carefully further on in this article

MODERN CONCEPTS OF CAVITY FORMATION AND CLOSURE

Mechanics of respiration For a better appreciation of the development of tuberculous cavities following initial tuberculous lesions, certain anatomical and physiological features of the lungs should be reviewed Anatomically speaking, the lung is situated between the bronchi on one aspect and the pleura or chest wall on the other Because of this relationship, pressure potentials are conveyed from one to the other through the medium of the lung parenchyma The lung tissue itself contains elastic fibers which are so arranged in their architectural distribution as to cause the lung constantly to contract upon itself around its bronchi There is thus a tendency for the lung constantly to pull away from the chest wall This is prevented by virtue of the potential vacuum existing between the parietal and visceral pleura *In utero* there is no pressure potential, the lung is atelectatic and the chest wall is relaxed around the collapsed lung Negative interpleural pressure develops at birth with the first diaphragmatic contraction The chest wall after birth tends to grow more rapidly than the lung which results in an increase in negative interpleural pressure This tends to cause the lung to inflate, the degree of inflation being limited by the contractile power of the elastic tissues Because of this phenomenon the so called complementary space in the posterior costophrenic angle never fills out in the adult During normal inspiration inflation of the alveoli is brought about by forces derived from the expansion of the thoracic wall and the descent of the diaphragm This results in an increase of negative pressure within the pleural space, which pulls the visceral pleura to the chest wall and the diaphragm and causes enlargement of the lung At the same time the bronchi tend to lengthen and there is an increase in the size of the bronchial

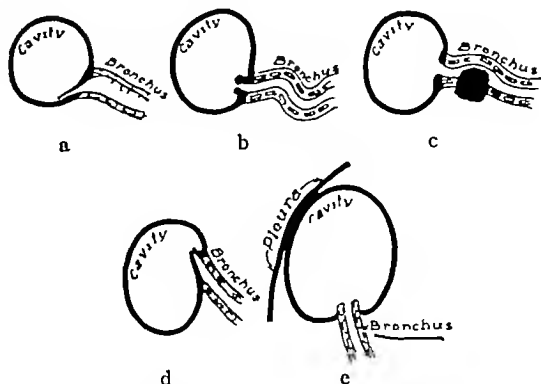


Fig 4 Common types of check valve mechanism (Courtesy Goldman, Brunn, and Ackerman, *Am Rev Tuberc*, 1941, 43: 151) **a.** Check valve, Closed when intra-cavitary pressure increased, open when it is decreased as with suction, air flow from bronchus to cavity only **b.** Accordion action valve, Closed as chest wall collapses in expiration frequently obstructed by secretions, tends to open with decreased pressure or suction **c.** By pass valve, Closed on expiration, open on inspiration, frequently obstructed by secretions **d.** Flutter valve, Closed on expiration, open on inspiration, air flow from bronchus to cavity only **e.** Nonvalvular, Open on both phases of respiration, air flow from bronchus to cavity and from cavity to bronchus equally, cavity held open by attachments to pleura

lumina which facilitates the entrance of air into the alveoli In the expiratory stage the intra-alveolar pressure moves from atmospheric to the positive side where it remains until sufficient air has escaped through the bronchi to return the intra-alveolar pressures to those of the atmosphere During this phase it should be remembered that the bronchi become shorter and smaller, thus it requires a somewhat longer time for intra-alveolar pressures to reach atmospheric levels at the end of expiration than it does at the cessation of inspiration It is quite apparent that during inspiration the alveolar spaces must, of necessity, increase in size, the degree of their expansion is limited by two forces, the strength of the negative pressure created in the pleural space on one hand and the strength of the elastic tissue on the other When the elastic tissues, that is the alveolar walls, have been damaged, this expansion of alveolar spaces will be very much greater during inspiration and there will be little, if any, tendency toward a return to normal size during expiration

1 Biological aspects of cavity formation Until comparatively recently the belief was held by the majority of pathologists that tuberculous pulmonary cavities have as their starting point caseous necrosis which involves both parenchyma and small bronchioles The products of necrosis



Fig. 5. Photograph of lung specimen, showing residual cavity permitting after multiple thoracoplasty. Probe is in the bronchus with its tip protruding into the cavity lumen, pushing away from the mouth of the bronchus trap-door like flap.

empty into the more distal bronchi thus, by "thawing" of the tubercles, a cavity is formed connected with one or several bronchi (Charcot and Richer).

Progressive destruction of pulmonary parenchyma leads to increase in size by coalescence eventually a lobe or an entire lobe may thus be transformed into a cavity. Unquestionably certain cavities are formed in this way and we feel that the biological factor in cavity formation should not be entirely supplanted by the more recent mechanical concepts.

- (2) Mechanical aspects of cavity formation—intracavitary factors Pinner (26) 928, and again in 193 (29) advanced the view that there is at first an infiltrative lesion which is followed by central necrosis and loss of tissue. The space thus produced grows larger due to contraction of radially placed elastic fibers which tend to pull the cavity walls apart. Pinner states that "all cavities are pathologically a product of well known tissue alterations characteristic of tuberculosis: the interplay of caseation, liquefaction, resorption and

fibrosis with the peculiar mechanical condition existing within the pulmonary parenchyma accounts for the striking structural differences of cavities at a given time in their development. The movements of the diaphragm and thoracic wall during inspiration exert traction on the lung which extends through to the cavity wall and the traction thus produced tends to pull the cavity walls apart. The centrifugal movement of the cavity walls may be accentuated by direct adherence of the cavity wall to the pleura or by bands of scar tissue connected with pleura or mediastinum and favors increase in cavity size. During expiration compression occurs from outside simultaneously with increase of pressure within the cavity. The lung parenchyma directly surrounding the cavity is thus caught between two opposing forces and results in compression of a zone of parenchyma around the cavity (Monski 20-21).

(3) Intracavitary factor It was shown by Hall and later by Pearson, Brooke, Corylles (9, ...) and others that certain cavities are in communication with a partly blocked bronchus and may exhibit increased intracavitary pressures. Gaseous pressures are set up within the cavity which exert an influence on the cavity wall the pressures within the cavity decrease on inspiration and tend to increase on expiration. The pressures will vary according to the patency of the draining bronchus or bronchi (see Figs. 2 a 3, a and 3 b). A tension cavity develops where there tends to be partial bronchial obstruction permitting the entrance of air into the cavity more freely than the escape of air. Such cavities have also been described as ballooning, check, or ball valve cavities (see Figs. 3, a and 3 b which graphically depict the forces at work in a cavity with a valvular draining bronchus). It will be observed that both during inspiration and expiration there are forces at work which tend to dilate the cavity walls. The valvular mechanism which produces a tension cavity may be located within the cavity or within the bronchial lumen (Fig. 4). The intracavitary check valve may be composed of caseous material or mucus and in other cases result from granulation tissue which partially overgrows the mouth of the bronchus. We have in our series found 1 such intracavitary check valve mechanism at autopsy; both of these cases had residual tension cavities that persisted in spite of thoracoplasty which in one case was most extensive (Figs. 5 and 6). The bronchus or bronchi draining a cavity may be partially occluded to form check valve mechanism, which may be caused by (1) growth of the bronchial mucosa (2) tuberculous infiltration (3) tuberculous ulceration (4) partial

stenosis of the bronchial lumen resulting from peribronchial scar formation. A partial encroachment of the lumen of a draining bronchus may be such as to permit the passage of air through into the cavity during the inspiratory stage when its lumen is greatest, but will not permit the exit of air during the expiratory stage, when the bronchi have contracted and their lumina have subsequently been decreased (Fig 4). There is today, a most comprehensive literature far too extensive to quote here on the frequency of terminal bronchial tuberculosis as a causative factor of partial bronchial occlusion with resultant formation of tension cavities. According to Coryllos (10), giant cavities are divided into two main groups dependent on the patency of the draining bronchi (1), cavities with positive pressures or tension cavities, and (2), cavities with atmospheric pressures. He states that only wide patency of the draining bronchus can explain atmospheric pressures in the cavity, and points out that there is usually absence of fluid and a thick wall. The same author was of the opinion that complete and permanent blockage of a draining bronchus resulted in highly negative intracavity pressures with subsequent disappearance of the cavity.

Closure of cavity The mechanism of cavity closure with or without healing is still very much in dispute. Ameuille and Levesque, 1923, argue that closure of a draining cavity bronchus leads to retention of secretion, which they believe causes the cavity to enlarge rather than to shrink. Pinner (27) 1937, states that available anatomical evidence does not favor the claim of Coryllos and others that bronchial occlusion is the sole, or even a contributory mechanism in cavity closure with collapse therapy, in fact he claims that pulmonary tuberculous cavities are almost invariably found to have secondary infection. In his opinion, therefore, a bronchial obstruction is a serious complication, resulting in cavity progression and toxic manifestations. More recently Pinner (28) 1940, admits that some tuberculous cavities are not secondarily infected and says that "there is no doubt that bronchi draining cavities may become occluded without causing the clinically malignant event of sputum retention." Eloesser 1937, writing on what he terms "blocked cavity," went so far as to state that "permanent obstruction, if there is such a thing, is also a factor that causes cavities to resist attempts at closure, it is because their bronchial outlets are stenotic that some cavities persist." Completely at variance with the views of Ameuille are those held by Coryllos and his coworkers (9, 10), who believe that the condition of a draining bronchus is the most important



Fig 6 Lung specimen, showing bilateral residual cavities persisting after bilateral upper stage thoracoplasty

factor in the closure of a cavity. A valvular mechanism in the draining bronchus results in giant "tension cavity," whereas complete closure of the draining bronchus, according to Coryllos (10), must result in closure of the cavity. We also believe that complete obliteration of a draining bronchus is absolutely essential to obtain permanent closure of any cavities. In our own experience at autopsy we have never seen a completely closed cavity without obliteration of bronchus or bronchi. Usually the bronchus can be traced directly to scar tissue into which it disappears. Salkin, Cadden, and McIndoe, 1936, studied 147 cavities, of which 14 per cent did not communicate with a bronchus. The investigation of cavities was carried out on cadavers, the cavities being injected through the chest wall with lipiodol in an attempt to outline the bronchial communication of each cavity. It is possible that, by this technique, bronchi which may have been open during life became blocked with caseous material or with mucus after death. Such cavities having bronchi thus temporarily blocked would fail to show a bronchial communication with lipiodol injection. Our own experience has taught us that a most careful search must be made for bronchial cavity communication. In 3 of our cases the pathologist reported no evidence of bronchial communication, 2 of the patients had had previous thoracoplasty without closure of the cavity and the intracavitary pressures had been taken during life in both cases and found to be on the positive side. It was thus clear that in both we were dealing with residual tension cavities which resisted any attempt at closure by thoracoplasty. With this in mind a re-examination of the specimens by one of us was conducted, each and every



Fig. 7 a.

Fig. 7 b.

Fig. 7 a. Large thick-walled apical cavity with positive pressure. Marked reduction in size after month of intracavitary suction drainage. b. Bilateral thin-walled cavities.

Roentgenogram indicates bilateral apical *brevis* cavities. Intracavitary pressures determined by needle: left, tension cavity; right, non-tension cavity.

bronchus in the vicinity of the cavity was carefully probed in the direction of the cavity. Two or three bronchi were probed and were found to end blindly and to have no communication with the cavity. Finally, however, in each case bronchus was found which permitted easy passage of the probe into the cavity lumen. As the probe entered the cavity a trapdoor-like flap of tissue was lifted away from the cavity floor revealing the mouth of a draining bronchus. The valvular mechanism thus demonstrated, guarding the lumen of a draining bronchus, explained the reason for increased pressures in the cavities and likewise why these cavities failed to collapse following extensive thoracoplasty. Agestach and Green, 1940, in a most careful anatomical and pathological study present almost irrefutable evidence concerning the important rôle played by a bronchus in the closure of its cavity. They state that "Up over two thousand (2,000) cavities observed by us, we have never seen an open cavity with a diameter of 3 cm. or more in which we were unable to trace with slender probe bronchus opening into the lumen of the cavity." They state further that the presence of tuberculous bronchitis which will lead to occlusion of the lumen of a bronchus is of frequent occurrence. Bronchi almost invariably show the same tuberculous process as that seen in their respective cavities.

Cavity wall. For many years collapse therapists and pathologists interested in collapse therapy stressed the importance of the cavity wall in cavity closure. It was felt that cavities of a chronic variety which showed a thickened wall by x-ray would be of the type I resist efforts to bring about collapse, whereas the thin wall apparently containing much elastic tissue was thought to be

good type for thoracoplasty as for example the cavities referred to by Pinner (29) as type II. If one examines carefully the x-ray reproductions of what Pinner (27) terms a type II cavity one is reminded of the tension cavities of Cornil. We know that such a cavity, in spite of its thin walls, is most resistant to collapse. Therein, due to the bronchial valvular mechanism which empties the balloon off the cavity walls. We have also seen many cavities which prevented, by way of extremely thick walls, both have responded extremely well either to extrapleural thoracoplasty or to intracavitary suction drainage. Monck and his school hold that in the tension type of cavity the thickness of the cavity wall is largely made up of an outer zone of elastic-like tissue. It is his view that intracavitary suction drainage by reducing the intracavitary pressure permits the elastic zone of parenchyma to re-expand by filling the re-expanded lung tends to fill in the cavity space. The result of the re-expansion of collapsed lung is to increase the blood supply brought to the wall of the cavity. They are unquestionably cavities with a rigid wall formed of thick fibrous tissue as described by Pinner in his type III cavity. Monck and others, however, are of the opinion that this type of cavity is extremely rare, such cavities, when they do occur, offering considerable resistance to collapse therapy. We are of the opinion that this latter type of cavity cannot be diagnosed by x-ray as unambiguously. In fact, in our experience reliance upon x-ray estimation of large apical cavities can lead to serious error. As previously stated, we have seen thick-walled cavities, which from x-ray appearance would fit into the Pinner type III classification, respond quite readily to collapse

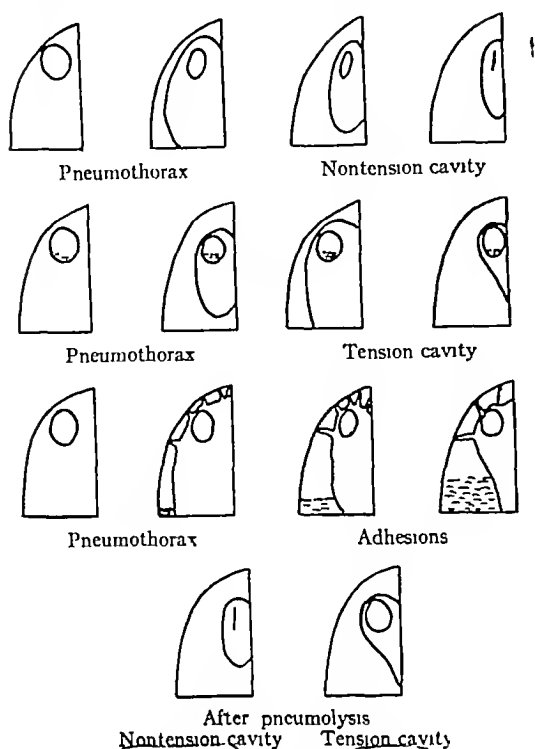


Fig 8 a, Effect of pneumothorax and pneumolysis

therapy (Fig 7, a) Likewise, not infrequently our radiologists report a tension thin walled cavity which, upon needling, is revealed to have a slightly negative or atmospheric intracavity pressure (Fig 7, b) In general, x-ray films do not help in the estimation of the cavity's response to collapse therapy

MECHANICS OF COLLAPSE THERAPY (Fig 8 a, b, and c)

Extrapulmonary collapse In extrapulmonary collapse the object is to obtain physiological rest of the diseased areas and at the same time bring about closure of the cavities. This can be accomplished only by diminishing or abolishing the extracavity forces which continuously tend to pull the cavity wall apart. When one or more of these forces are decreased, such as occurs in phrenic nerve interruption with paralysis of the diaphragm or when the chest wall pull is released by thoracoplasty, the lung, if it is sufficiently elastic, will collapse upon itself. The effect upon the cavity will depend largely upon two factors, namely (1), the flexibility of the cavity wall, and (2), the condition of the draining bronchus. In

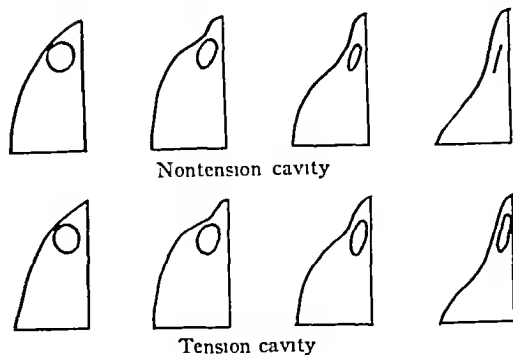


Fig 8 b, Effect of thoracoplasty

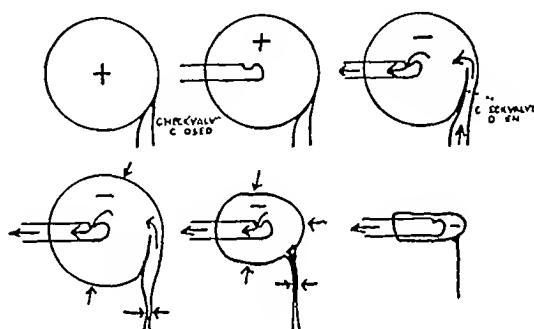


Fig 8 c, Effect of transthoracic suction drainage

that rather large group of cases in which the cavity wall is flexible but the intracavity pressures are high, due to a bronchial valvular mechanism, collapse of the cavity by release of extracavity forces alone cannot be expected (Fig 9) No matter how extensive the thoracoplasty or how complete the pneumothorax the cavity must, of necessity, remain open. The collapse procedure simply changes the location of the cavity without influencing the positive intracavity pressures which are constantly ballooning out the cavity wall. We have seen cavities drop from the apex to the fourth rib following a Semb apicolysis with thoracoplasty, and although reduced in size they are still very much in evidence. On the other hand we have observed giant cavities which, because of their size, appeared impossible to close by thoracoplasty. Much to our surprise, such cavities have collapsed in an accordion-like fashion at the end of the second stage of thoracoplasty (Fig 18, c) Cavities which have behaved in this fashion were known to have a widely patent draining bronchus or bronchi, the patency of the bronchi was proved by intracavity pressure readings which were atmospheric or slightly negative

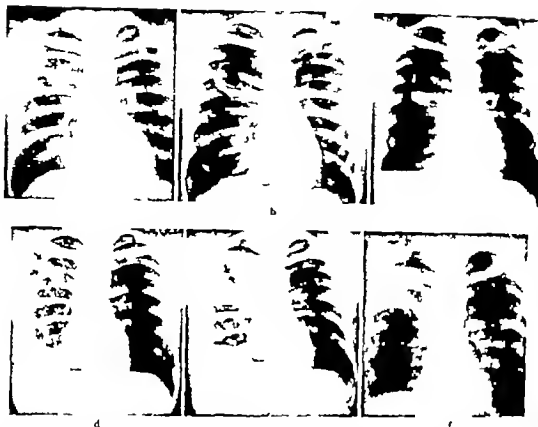


Fig. 9. Positive-pressure cavity converted by efficient artificial pneumothorax. a, Original cavity. b, inefficient artificial pneumothorax due to adhesions. c, efficient pneumothorax following pneumolysis. d, effect on cavity.

d, re-expansion of the lung. Intracavitary pressures are positive. e, cavity reduced by intracavitary suction. f, after 1, lipoidal emulsion into same track—cavity closed. 1, size of catheter. Bronchoscopy still open.

Intrapleural collapse. Tension cavities are maintained by alveolar mechanism which exists within the lumen of the cavity or its draining bronchus. The forces maintaining inflation of the cavity are thus affected by extrapleural collapse. Monaldi recognized this fact and sought to overcome intracavitary forces by inserting catheter directly into the cavity lumen with subsequent application of continuous suction. According to Monaldi's conception of tension cavity there is a ring of atelectatic lung tissue surrounding it. During expiration positive intracavitary pressures expand the cavity walls at the same time as the surrounding lung contracts; hence the lung parenchyma directly round the cavity is caught in between opposing forces and a ring of atelectatic lung results. Intracavitary suction prevents the building up of positive pressures and, according to Monaldi, permits the atelectatic

zone to re-expand. The re-expanded lung is certain directly develops compensatory emphysema, which helps to obliterate the cavity space. The re-expansion of previously atelectatic lung tissue permits an increased blood flow in the region of the cavity wall. This is thought by Monaldi to be of value in the healing of the cavity. As the suction is continuous, sputum, caseous material and other cavity debris is continuously separated. Monaldi suggested that the removal of disease products by suction might convert cavities of the "inert" type into "retractile" ones.

Chance's oil procedure. A consideration of some of the factors responsible for cavity formation and closure show quite clearly that the condition of the draining cavity bronchus must be known before surgical collapse therapy is attempted. This information can be obtained only through a complete study of the intracavitary

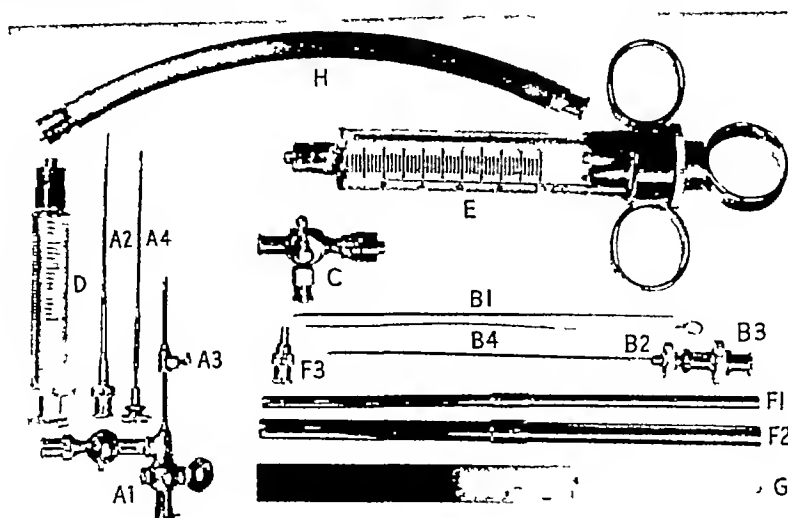


Fig 10, Authors' instruments devised to avoid common complications occurring during determination of intracavitary pressures or institution of transthoracic cavity drainage. A, Directing needle (modified initial pneumothorax needle), B, exploring needle, C, three way stop cock, D, 2 cubic centimeter Luer Lok syringe, E, 10 cubic centimeter Luer Lok syringe, F, Wangensteen cannulae, G, ruler, H, rubber tube connection with manometer

pressures The authors (34) in a previous article have pointed out that "a condition of an entering bronchus generally cannot be observed by bronchoscopic examination—the bronchoscope will demonstrate only where there is a partial bronchial stenosis in the first order of bronchus—negative bronchoscopic examination, therefore, does not rule out disease in the fourth or fifth order of bronchus, which might be draining the cavity under consideration" We were, and still are, of the opinion that intracavitary pressure readings should be taken in all cavities larger than 2.5 centimeters prior to attempting thoracoplasty. If the pressures are such as to indicate the presence of a tension cavity then thoracoplasty as an initial measure should not be undertaken. Failure to recognize a tension cavity before beginning a multistage thoracoplasty accounts, we believe, for a considerable number of residual cavities. The residual cavity persists in the presence of, and in spite of, what appears to be a technically excellent collapse. The authors (34) reported 12 residual cavities in 119 completed thoracoplastic cases, in which the intracavity pressure readings were found to be highly positive. "We do not wish to imply that all residual cavities having highly positive pressures were originally tension cavities. It does, however, seem logical to deduce that the positive pressure cavity found open after a multistage thoracoplasty was probably a tension cavity

to begin with." In the treatment of tension cavity it is, therefore, our opinion that an attempt to close the cavity should be made first by intracavitary suction drainage. Those cavities which by intracavitary pressure reading and study are considered to have a wide open draining bronchus with atmospheric pressure respond most favorably, in our experience, to thoracoplasty. Thoracoplasty is therefore indicated in atmospheric or negative pressure cavities.

METHOD AND INSTRUMENTS FOR DETERMINING INTRACAVITARY PRESSURE

Instruments The instruments used for measuring intracavitary pressures and for establishing closed intracavitary suction drainage were designed by us and are shown in Figure 10. A 16 gauge Küss initial pneumothorax needle, A1, has been fitted completely with Luer-Lok connections including a blunt stilet, A2, thus insuring an airtight system. On the shaft of the Küss needle there is a sliding collar, A3, which can be fixed at any point by a thumbscrew. The exploring needle, B, consists of a 19 gauge shaft, from 12 centimeters up to 18 centimeters in length, B1 and B4. The hub, B3, of the needle can be attached to the shaft at any point by means of a screw lock, B2. The screw lock contains a small rubber washer and makes an airtight connection with the hub. The length of the nee-

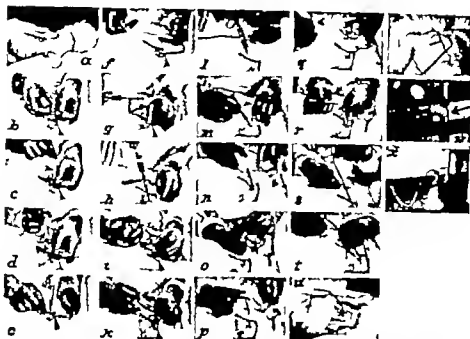


Fig. 1. Operative technique of trans-thoracic intracavitary pressure reduction and suction drainage. *a*, Patient in prone position. Cavity projected to anterior surface by fluoroscopic examination. Note scar of anterior thoracoplasty. *b*, Introducing of directing needle. *c*, removal of sharp trocar. *d*, introduction of blunt trocar. *e*, attached syringe. *f*, manometer connected. *g*, adjusting length of needle shaft. *h*, exploring needle assembled with *g*. *i*, stopcock and syringe filled. *j*, skin incision. *k*, exploratory needle in cavity, aspiration of air through syringe. *l*, removal of hub of exploratory needle and *m* way stopcock. *n*, removal of directing needle. *o*, search for blood vessels.

p, incision of skin. *q*, coagulating current applied to needle shaft. *r*, Wangensteen cannula, upper and lower (cut) halves. *s*, cutting half introduced over needle shaft into the cavity. *t*, cutting half in position, removal of needle shaft and application of coagulating current. *u*, cutting half of larger cannula slipped over assembled halves of smaller cannula. *v*, Nelaton catheter size 14, introduced into the cavity through larger cannula. *w*, cannula withdrawn, catheter in place. *x*, catheter fastened with *y* sutures and adhesive. *z*, dressing with special bandage. *aa*, Fumeberry pump with attached vacuumeter placed in basement of institution; *ab*, Davidson suction bottle attached.

the shaft required is measured by a steel ruler. *G* The two metal cannulae *F₁* and *F* were designed by Wangensteen for drainage of lung abscesses. They have been modified to take a Luer Lok hub, *F₂* at the noncutting end. The hub fits both cannulae.

Technique. (Fig. 1 *a* to *z* adapted from a 6 millimeter motion picture in color prepared and filmed by the authors.) In cases with cavity referred to the surgical service for thoracoplasty either there has been an inefficient pneumothorax with adherent apex or it has been found impossible to induce pneumothorax. Even though the pleural space directly over the cavity appears to be obliterated, there may be small residual areas in which the parietal pleura is not adherent. To avoid infecting the pleural space when needling a cavity we use a modified 16 gauge Kuss needle through which a longer needle, of 19 gauge and

5 to 18 centimeters in length, can be introduced. Both needles are fitted with Luer Lok connections. Under local anesthesia, the Kuss needle with its trocar is introduced through the intercostal space down to the parietal pleura (Fig. 11 *b*). The trocar is removed (Fig. 11 *c*) and replaced by the blunt stylet, which is connected to a 2 cubic centimeter Luer Lok syringe (Fig. 11 *d*). The parietal pleura is then punctured and manometer attached to the side arm of the instrument by rubber tube (Fig. 11 *e*). If a free pleural space is encountered, the needle is immediately withdrawn and reintroduced at another point. When the pleural space is found to be obliterated and no pressure reading obtained the sliding collar on the Kuss needle is set. The Kuss needle is thus at all times kept at the same distance as regards both the pleural space and the cavity. The distance from the chest wall to the cavity has been pre-

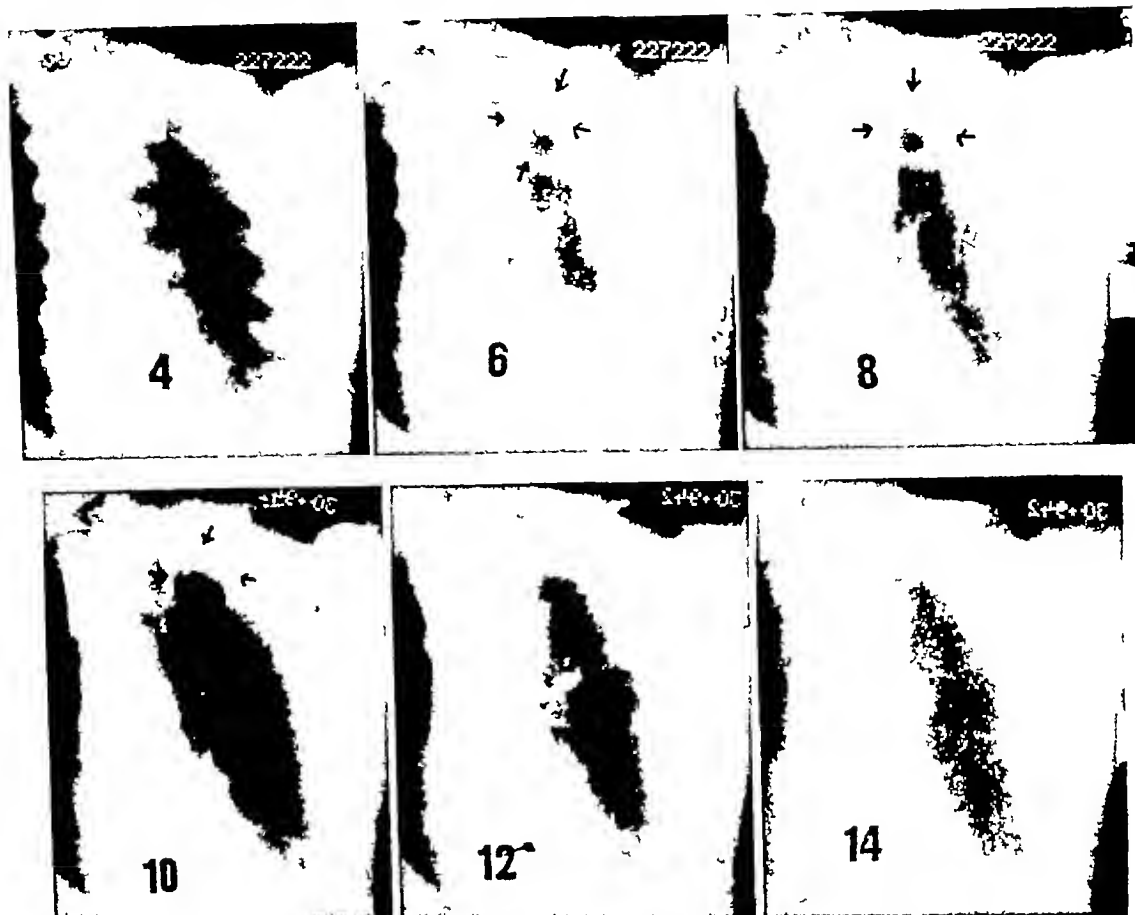


Fig 12 Tomographic study of apical cavity The distance of the cavity from the posterior chest wall is shown on each film in centimeters (Courtesy of Dr C B Peirce, Royal Victoria Hospital, Montreal)

ously estimated by means of the tomograph (Fig 12) The latter distance, added to the distance from the chest wall to the hub of the Küss needle, gives the approximate length of the exploring needle which will be required This length is measured on the shaft of the exploring needle and the hub is set at the desired point by the adjustment of the lock screw (Fig 11, f) The hub of the exploring needle is now attached to a three way stopcock, which is also connected to a syringe containing saline and to a manometer (Fig 11, g) The exploring needle is now introduced through the lumen of the Küss needle until the lumen of the cavity has been entered (Fig 11, h) As the exploring needle penetrates the chest and cavity wall it is important to keep the stopcock turned in the direction of the syringe The plunger of the syringe is constantly being withdrawn as the nee-

dle is pushed ahead, this is done in order to detect blood vessels in its path and also to know when the cavity lumen has been entered The saline in the syringe guards against possible air embolism which could occur if a large blood vessel were encountered There are two ways of knowing when the exploring needle has entered the cavity The first is the sudden release of resistance which is felt as the needle finally penetrates the thick cavity wall, the second is the entrance of air into the saline filled syringe (Fig 11, h) As soon as air enters the syringe the stopcock on the exploring needle is immediately turned so as to obtain manometric readings, in this way, very little air is withdrawn from the cavity and none is allowed to escape The initial intracavitary pressures cannot be accurately recorded, unless these precautions are taken to pre-

vent loss of air, the intracavitary pressures will be temporarily reduced. This will result in intracavitary pressure readings which will in no way be a true measurement of the initial pressure present before needling. The positive intracavitary pressures recorded in the literature by many observers are for the most part on the low side, the reason for such low pressures becoming quite clear when one examines the methods used.

Interpretation of intracavitary pressure readings

At the Grace Dart Home Hospital we have found it necessary to standardize pressure readings, particularly with reference to the different phases of respiration. After insertion of the needle into the cavity it is best to permit the patient to quiet down before recording the pressure. In all cases the pressure readings are recorded in the following sequence: initial pressure, quiet breathing after cough, following withdrawal of air, after the introduction of air. The pressures within a cavity depend almost entirely upon the patency of an entry bronchus or bronchi.

A record of the cavity needling is kept on a special form (Fig. 13, a).

Estimation of such pressure, therefore, conveys a clear functional picture of bronchial patency (kymographic records, Figs. 1, 2 and 3). Corvillo (10) has classified cavities according to their intracavitary pressures and divides them into three main types, namely negative, atmospheric, and positive pressure cavities. Manometric oscillations change rapidly between inspiration and expiration. By taking the highest and the lowest manometer readings, a mean average is obtained in order to ascertain into which group the cavity belongs by virtue of its intracavity pressure.

Negative pressure cavity with completely blocked bronchus

"Initial pressure, $-10, -7$
Forced breathing, $-12, -5$
Quiet breathing after cough, $-10, -7$
Withdrawal of air, $-18, -12$ where it remains
Introduction of air, $+4, +8$, where it remains"

A cavity showing a negative pressure reading has temporarily no connection with a bronchus. The higher the negative pressure, the older the bronchial occlusion. When the pressures are negative, but close to the atmospheric, the bronchial closure was probably of recent origin and may be quite temporary, for example, if it is plugged by mucus.

Atmospheric pressure cavity, open bronchus

"Initial pressure, $-3, +3$
Forced breathing, $-8, +8$
Quiet breathing after cough, $-3, +3$
Withdrawal of air, $-3, +3$
Introduction of air, $-3, +3$ "

The greater the oscillation, the smaller the bronchus. When there is a large and patent bronchus there are practically no oscillations, and the pressure is approximately zero.

Positive pressure cavity, check valve bronchus

"Initial pressure, $-2, +2$
End of inspiratory phase, -2 , goes to 0
End of expiratory phase, $+2$, remains steady
Forced respiration, $-4, +4$
Quiet respiration, 0, $+4$
Cough, $+30$
Quiet respiration after cough, $+6, +10$
Withdrawal of air, $-2, +2$
Introduction of air, $+6, +10$ "

INDICATIONS FOR CLOSED TRANSTHORACIC INTRACAVITARY DRAINAGE

Tension cavity The only true indication for intracavitary suction drainage is that of a tension cavity or cavities larger than 2.5 centimeters, which have been proved by needling of the cavity and the recording of positive pressure.

Contraindication We are not prepared to advocate suction drainage of large cavities with negative or atmospheric pressures when such cavities usually respond so well to thoracoplasty. Many of the cases reported in the literature which were treated by suction drainage were of the atmospheric type, which fact in part may account for some of the failures recorded. A very sick patient in whom the disease is rapidly spreading to other parts of the lung or lungs should not have intracavitary drainage. It should be remembered that intracavitary suction drainage works by overcoming unfavorable local mechanical factors. The general clinical improvement which follows suction drainage is probably due to aspiration of debris and other toxic products which were previously absorbed. The closing of one cavity may slightly influence disease elsewhere, but it is not likely to increase general immunity sufficiently to arrest a widely spread and progressively active lesion. Treatment of such cases because "they are doomed" or because "if it does not do them any good cannot do them any harm," simply throws discredit on the procedure and should be avoided. There is, however, no contraindication to the treatment of bilateral tension cavities or of multiple tension cavities on the same side.

Free pleural space A free pleural space is a definite contraindication to transthoracic intracavitary drainage. The space should first be obliterated before proceeding. In our series we have encountered 15 free pleural spaces, of these 8 were obliterated by the injection of whole blood into the pleural cavity, by the technique of Kupka and Wagner and one by introduction of sulfathiazol powder suspension in saline solution. A proper obliteration of the pleural space is very important. In the absence of solid pleural symphysis transthoracic intracavitary puncture may result in a

tuberculous empyema with or without a bronchocutaneous pleural fistula.

Expanded pneumothorax In those cases in which pneumothorax has failed to close the cavity and it is decided that other measures of collapse therapy are to be instituted it is very important to make certain that the re-expanded lung has become firmly adherent. We have had experience with one case of this type in which there appeared to be good symphysis of the pleura as indicated by repeated needling with initial pneumothorax needle actually on introduction of the cannulae the visceral pleura was pushed ahead and, fortunately was recognized before the cavity was entered and resulted in no harm. We feel that a minimum of 2 months should elapse following the complete re-expansion of a pneumothorax before trans thoracic intracavity drainage is attempted, in order to insure strong pleural symphysis.

Location of cavity Cavities located near the hilar region are difficult and dangerous to drain. The large pulmonary vessels are too close for safety.

Hemorrhage Hemoptysis is a definite contraindication to trans thoracic intracavity drainage, particularly if it has been established that the blood is coming from the cavity to be drained.

CLOSED TRANS THORACIC INTRACAVITY DRAINAGE

We have previously stated that it is of the utmost importance to know intracavity pressures prior to instituting thoracoplasty. When apical cavities are shown to have constant pressures it would seem logical to reduce those pressures before thoracoplasty is performed, although a cavity having a positive pressure before thoracoplasty may become a negative pressure cavity after the first or second stage. Nevertheless, the evidence, both pathological and physiological, argues against this probability. It is difficult to see how a diseased bronchus would be very much changed by dropping the cavity down to the level of the third or fourth dorsal vertebra. With this in mind we have felt that all positive pressure cavities should have direct intracavity suction drainage. The so called Monaldi method or closed trans thoracic intracavity drainage maintains a consistently negative pressure in a formerly positive pressure cavity and results in ultimate closure or reduction in size of a high percentage of large cavities. It is generally conceded that intracavity suction drainage as a collapse measure is only partially successful.

Preoperative procedure Prior to the trans thoracic intracavity drainage it is ab-

solutely imperative that the parietal and visceral pleura be proved to be adherent. This adherence must be over a large area. In addition to the use of the technique described for intracavity pressure reading, it has been our custom to needle the thorax with a sterile 18 gauge needle at four or five different points in the region over and around the cavity. In those cases in which we find the pleura only partially adherent the small pockets are injected with the patient's blood for purpose of obliteration.

Operative technique (Fig. 11) The patient is given $\frac{1}{2}$ grain of morphine and 1/100 grain of scopolamine. On the operating table the supine position is used (Fig. 11 a). The neutral electrode of the coagulating current is placed securely in the dorsal region. Under local anesthesia the exploring needle is introduced through the first interspace approximately in the midclavicular line, directly into the cavity as previously described (see Technique of Intracavity Pressure Readings, Fig. 1, a to b). Intracavity pressure readings are taken. The hub of the exploring needle which was left in its original position in the cavity is removed (Fig. 11 c) and the Kist needle is withdrawn (Fig. 11 d). A 20 gauge spinal needle with syringe filled with saline is used to examine the region adjacent to the exploring needle (Fig. 11 e). This is done in order to determine the presence of large blood vessels which might have been missed by the exploring needle and yet would not be missed by the larger cannula. Each time that the spinal needle is used it is inserted directly into the cavity. This is done over an area slightly larger than the largest cannula to be inserted. The skin and subcutaneous tissue are incised about half a centimeter on either side of the exploring needle (Fig. 11, m). The active coagulating electrode is applied to the needle shaft for approximately 20 seconds (Fig. 1 n). This had been established for our machine as the time necessary to coagulate zones of millimeters around the needle on fresh beef lung. The cutting half of a medium-sized Wa. Jensen cannula is now slipped over the shaft of the exploring needle and pushed into the cavity (Fig. 11 o, p). The exploring needle is withdrawn and the active coagulating electrode applied again (Fig. 1 q). The second half of the medium-sized cannula with its attached Luer Lok adapter is connected to the first half. The intracavity pressures are taken again to ensure that this cannula is within the cavity. There is usually an audible exchange of air after the cannula has been introduced into the cavity. The adapter is removed, and the cutting half of the large sized cannula is passed over the

first cannula and pushed through the chest wall into the cavity (Fig 11, r). The first cannula is removed and the upper half of the large sized cannula is attached. The coagulating current is again applied to this cannula and the pressure readings are taken. The upper half of the cannula is unscrewed. A size 14 Nelaton catheter is used. Two extra holes of good size are cut in the catheter, all near the tip, while a piece of linen thread is tied around the catheter. This is placed at a distance from the tip so it will be flush with the skin when the tip is in the cavity. The catheter is introduced through the cannula (Fig 11, s) and the cannula is then removed (Fig 11, t). One silk-worm stitch is used to close the skin. The tube is held in place by a piece of quarter inch tape which is tied around the tube to the linen thread marker. Both ends of the tape are fixed to the skin by adhesive tape (Fig 11, u). The dressing is kept in place by a special binder (Fig 11, v) including a changeable piece of washed x-ray film.

Suction. During the first 48 hours the catheter is aspirated with a 20 cubic centimeter syringe three times daily. If at the end of 48 hours there is no longer blood streaked sputum, suction is applied to the catheter. There are two methods of suction. The first is that of intermittent negative pressure, which was advocated by Monaldi, who used the two bottle system, the second that of constant pressure produced by a water, steam or electric pump. Monaldi prefers the former because he was of the opinion that continuous suction traumatized the lung tissue.

At the Grice Dart Home Hospital we have employed continuous suction. A Pemberton hydraulic ejector, usually used for evacuation of stagnant water in mines, cellars, etc., has been placed in the cellar of the institution from which pipe lines have been led into two of the wards (Fig 11, w, x), thus a continuous source of negative pressure is constantly available at each bed.

The pump, having a $\frac{1}{4}$ inch supply connection, delivers under a water pressure of 40 to 60 pounds a vacuum of about 21 to 25 inches mercury, provided all suction outlets are closed. The vacuum drops down to 8 to 10 inches mercury, when approximately 12 to 15 patients are connected with the system, assuming an average individual suction pressure and an average size of bronchus or bronchi. The supply pressure, however, is throttled down to about 5 inches mercury negative pressure which is still higher than the maximum suction pressure ever applied by the authors in these cases. (The highest heretofore was 6 cm Hg.) The vacuum supply is under constant control of the engineer on duty. This system was found a most reliable, simple and economic one after having experimented with various vacuum generators for a long time.

The degree of individual suction is controlled by a column of fluid within a Davidson (32) bot-

tle (Fig 11, x). Each case is started off with 2 to 3 centimeters water of negative pressure, which is gradually increased as required. We are of the opinion that continuous suction is necessary in order to obtain satisfactory results. The object of the suction is twofold, the first being to maintain constantly a negative pressure within a tension cavity and the second to aspirate the necrotic material and tubercle bacilli from the cavity lumen. We cannot understand how a two bottle system, which requires constant attention and changing can possibly fulfill these two requirements. If the draining bronchus is a large one the rate at which air is trapped in the cavity may quite easily exceed the speed with which it is withdrawn through the catheter. Indications for increasing suction are, therefore, (a) failure of the cavity to show any decrease in size after 1 week to 2 weeks of treatment, (b) the disce of catheter drainage. In our first patient we were faced with this problem and we slowly, week by week, increased the negative pressure until eventually a 6 centimeter column of mercury was used, with this very high negative pressure there was good catheter drainage and rapid closure of the cavity. For the first week to 10 days the patient suffered periodically from dyspnea and inability to catch her breath. There was no evidence of right sided heart failure and no blood tinged discharge from the catheter. We interpreted the period of paroxysmal dyspnea as being due to intermittent opening of the bronchus, which permitted suction of air out of the sound lung.

Continuity of suction. In most cases the suction is maintained approximately 12 hours daily and is discontinued at night. In certain resistant cavities it has been maintained throughout the entire 24 hours with beneficial rather than harmful results. As the general condition of the patient improves and the cavity grows smaller, the strength of the suction is gradually decreased.

Catheter. The catheter should be left in place for at least 10 days after its insertion into the cavity. We have found it expedient to insert the catheter more deeply into the cavity than is necessary. A well defined sinus tract will be formed at the end of 10 days. By this time it is safe to remove the catheter slowly under fluoroscopic control, leaving approximately an inch and a half of its tip within the lumen. Shortening of the catheter prior to 10 days, in our opinion, may result in the catheter coming out of the cavity, in which case it is almost impossible to reinsert it without repeating the entire procedure.

Permanent removal of catheter. The end of treatment is determined by (1), the complete disap-

pearance of the cavity as proved by tomographic studies (3) the absence of tubercle bacilli in catheter contents (3), negative sputum. In those cases however in which the sputum remains positive and the catheter drainage contents are negative, we have been able to show that the positive sputum was coming from a source other than that of the cavity under consideration. In such cases, suction drainage is discontinued, and is immediately supplemented by thoracoplasty.

Catheter withdrawal. This should be done slowly over a period of 3 or 4 weeks, although in many cases the catheter is slowly pushed out by the contracted lung.

COMPLICATIONS

Hemorrhage. In our series we have not experienced a single case of severe hemorrhage. Our technique for introducing the catheter into the cavity is designed to avoid this most unfortunate and usually fatal operative complication. In other clinics, after the exploratory needle has entered the cavity and it has been ascertained that the pleura is adherent a metal trocar and cannula are bluntly inserted alongside of the exploratory needle. In this way the trocar and cannula could quite easily puncture a large blood vessel which had been missed by the fine gauge exploratory needle. By the use of the technique here presented the cannula entering the lung cavity is guided there along the same path as was taken by the shaft of the exploring needle. It should also be noted that by using Wangensteen's cannulae the first cannula to enter the cavity has a diameter only slightly larger than that of the original needle. We believe that preliminary exploration with a second small gauge needle directly into the cavity in the zone around the first needle's shaft is a necessary safeguard against entering a large blood vessel.

Embolism. Certain precautions are taken to avoid this complication. The patient is positioned on the table so that his head and chest are lower than his feet. The exploratory needle passing through the lung is attached to a saline filled syringe. It is felt that the coagulating current applied to the shaft of the exploring needle and to each Wangensteen tube in succession, after it has entered the cavity, will seal small blood vessels which may have been opened by the passage of the needle or cannula.

Empyema. This can occur only if pleural anastomosis is incomplete or if insecurely complete such as occurs after pneumothorax. We attempt to guard against this complication by repeated punctures of the chest wall with a small pneu-

mothorax needle over an area much larger than the cavity itself. In the needling of the cavity it will be noted that the exploratory needle is inserted through an initial pneumothorax needle at a site which has previously been shown not to have a free pleural space.

Failure to collapse the cavity. In our series there has been a case of persistent drainage although this occurred after the draining of residual tension cavity persisting after thoracoplasty and in which suction drainage had to be discontinued because of the development of a pyothorax.

THORACOPLASTY AND THE TENSION CAVITY

We have previously stated that thoracoplasty as a collapse measure in the treatment of tension cavities is, and must be highly inefficient. The use of thoracoplasty however in conjunction with transbronchic intercostal suction drainage is essential.

Anterior thoracic plastic. Large pleural cavities which by tomograph and fluoroscopy are shown to be directly in contact with the anterior pleura should have a preliminary anterior stage thoracoplasty carried out before the institution of suction drainage. This we believe to be important in order to permit the cavity to collapse. When the cavity is deeply situated within the lung, suction drainage by preventing intracavitary tension permits of the collapse of the cavity. With re-expansion of the surrounding telescopic lung. However when one wall of the cavity is adherent to the chest wall, there is no intervening lung which can re-expand and help to fill in the space created by the cavity. The removal of the first three ribs anteriorly permits the chest wall to sink inward and thus helps to obliterate the cavity. The anterior first three ribs are removed efficiently by the posterior villous line so that after transbronchic intracavitary drainage has been well established and the cavity has shrunk to the size of a catheter, a posterior upper stage thoracoplasty can be carried out with safety while a catheter is still in place. In other cases in which the cavity has been deeply situated and no more posterior than anterior partial posterior stage thoracoplasty has been carried out.

A review of the literature on transbronchic intracavitary suction drainage makes it clear that cavities subjected to this type of collapse procedure will close but that the closure will not be permanent. Some of the reasons for re-expansion of such cavities few months after the instituting of suction drainage became apparent, as in our first case (see Case 7). A large pleural cavity was rapidly decreased by catheter drainage and thorac-

TABLE I

Disease	No of cases	Collapse procedure	Treatment completed				Under treatment				Death	
			No of cases	Sputum converted		Cavity closed tomogram	No of cases	Sputum		Catheter		
				Yes	No			Pos	Neg	Pos		Neg
UNILATERAL												
1 Nontension single cavity	8	Thoracoplasty	7	7	—	5	1	—	1	—	—	
2 Honeycomb cavities too small to needle	9	Thoracoplasty	7	7	—	5	2	—	2	—	—	
3 Positive pressure single cavity	9	I C S D	—	—	—	—	1	—	1	1	—	
		I C S D and thoracoplasty	3	3	—	2	5	2	3	3	2	
4 Honeycomb cavities with large tension cavity	3	I S C D	—	—	—	—	1	—	1	—	1	
		I C S D and thoracoplasty	2	2	—	1	—	—	—	—	—	
BILATERAL												
1 Nontension single cavity	8	Thoracoplasty	7	6	1*	3	1	—	1	—	—	
2 Honeycombing large nontension cavity	2	Thoracoplasty	1	1	—	1	1	1	—	—	—	
3 Honeycombing cavities too small to needle	1	Thoracoplasty	—	—	—	—	1	1	—	—	—	
4 Bilateral nontension cavities	1	Bilateral thoracoplasty	1	1	—	1	—	—	—	—	—	
5 Positive pressure single cavity	10	I C S D	—	—	—	—	4	4	—	2	2	
		I C S D and thoracoplasty	3	2	1	—	2	2	—	1	1	1†
6 Honeycombing with large tension cavity	1	I C S D and thoracoplasty	—	—	—	—	—	—	—	—	—	1‡
7 Tension and nontension cavity opposite sides	2	**	—	—	—	—	—	—	—	—	—	2
RESIDUAL CAVITIES												
1 Unilateral thoracoplasty	4	Packing	2	2	—	2	—	—	—	—	—	
		I C S D	—	—	—	—	2	2	—	2	—	
2 Bilateral thoracoplasty	1	Packing and I C S D	—	—	—	—	—	—	—	—	—	1¶
Total	59		33	31	2	20	1	12	9	9	6	5

*Positive sputum coming from contralateral side

†Converted sputum and catheter content. Cavity still open but greatly reduced in size. Dies of tuberculous meningitis six weeks after starting drainage.

‡Bilateral disease with large tension cavity left apex and multiple cavities on same side. Tension cavity closed by I C S D followed by thoracoplasty. Other cavities not closed. Death due to uremia.

**Case 1. Positive pressure cavity right apex, closed by suction drainage and upper stage thoracoplasty. Left apical nontension cavity closed by anterior and two stage posterior thoracoplasty. Died of foreign body aspiration pneumonia. Case 2. Right-sided nontension cavity closed by 2 stage seven rib thoracoplasty. Left apical tension cavity. Anterior thoracoplasty died from circulatory failure.

‡Intracavitary suction drainage one side. Died 6 weeks later of psychosis.

appeared to be closed. The sinus tract healed and the sputum turned negative. Stereoscopic x-ray pictures failed to show any evidence of the cavity. Tomograph x-ray pictures, however, showed a small residual cavity still open. With this evidence at hand, a 5 rib upper stage thoracoplasty was completed. A recheck by tomograph following thoracoplasty showed that the small residual cavity was completely obliterated. We have, since, taken the stand that intracavitary suction drainage will reduce and even close cavities but not permanently. Permanent closure of tension cavities can only be obtained in the vast majority

of cases by superimposing thoracoplasty to ensure permanency of closure.

RESULTS

In 70 patients an attempt was made to needle 76 cavities in order to ascertain whether they were of the tension or nontension variety. Of 63 cavities actually needled, 27 or approximately 42 per cent of the cavities in which the intracavitary pressures were taken proved to have a positive pressure (16 had negative pressures and 20 showed atmospheric pressure). These figures are of interest when one considers the frequency of residual

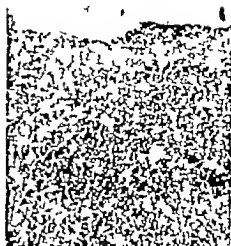


Fig. 14. A, left, Specimen of lung with labeled cavity. Catheter in place. B, above, Microscopic section (H&E stain) from cavity. All, 6 weeks after starting intracavitary suction drainage. Note the marked precavitary hyperemia and the apparent absence of destructive interlobular processes.

cavities following thoracoplasty. Thirteen cavities were not needed: 6 because they could not be located with the exploratory needle and 7 because the initial pneumothorax needle showed there to be free pleural space. In all, 50 needlings of cavities were completed in a total of 63 cases. On 5 different occasions the exploratory needle encountered a blood vessel. Further exploration of the cavity lumen was deferred in each of the 4 cases. There were no ill effects and no complications, that is, all needlings were accomplished without development of air embolism, empyema, or gross hemorrhage.

As we have previously stated, we are of the opinion that no surgical collapse measure should be undertaken to collapse cavities larger than 3.5 centimeters before the intracavitary pressures have been determined by needling. In this series of 59 treated patients, 5 of them had residual cavities following thoracoplasty; the 54 remaining patients had one or more cavities, 44 of which were tension cavities. The positive pressure cavities were all treated by transthoracic intracavitary drainage with or without thoracoplasty. In those cavities which were unusually large and in which the anterior wall of the cavity was in contact or adherent to the inferior parietal pleura, preliminary anterior stage thoracoplasty was carried out prior to the introduction of cavity drainage. All cavity drainage cases were subjected to an upper stage thoracoplasty as soon as was possible

following the closure of the cavity by suction drainage. In this series there are 22 cavities in which the pressures were negative or atmospheric. In all of these cavities posterior thoracoplasty is carried out. Transthoracic intracavitary suction drainage has not been carried out on the atmospheric or negative pressure type of cavity. There were 39 cases of unilateral disease and 25 cases of bilateral disease (Table I). It will be noticed that in this table the honeycomb type of cavity, which is too small to be needled, has been treated by thoracoplasty (10 cases). We are of the opinion that in cases in which there are honeycomb cavities they are most likely to have patent bronchi, otherwise they would inflate and form one or two large cavities.

The size of the cavities needled and treated in this series ranged from .5 by .5 centimeters to 11 by 8 centimeters. The average was approximately 4 by 5 centimeters.

Location of cavities. All those cavities which have had transthoracic intracavitary drainage were located at the apex. We have not attempted to drain hilar or basal cavities. In all cases the cavity is not considered to be closed unless proved by tomogram ray. We have divided our cases into those which are still under treatment and those which have completed treatment (see Table I) and have further subdivided our results into those cases under treatment for less than 3 months and those which have been treated for 3

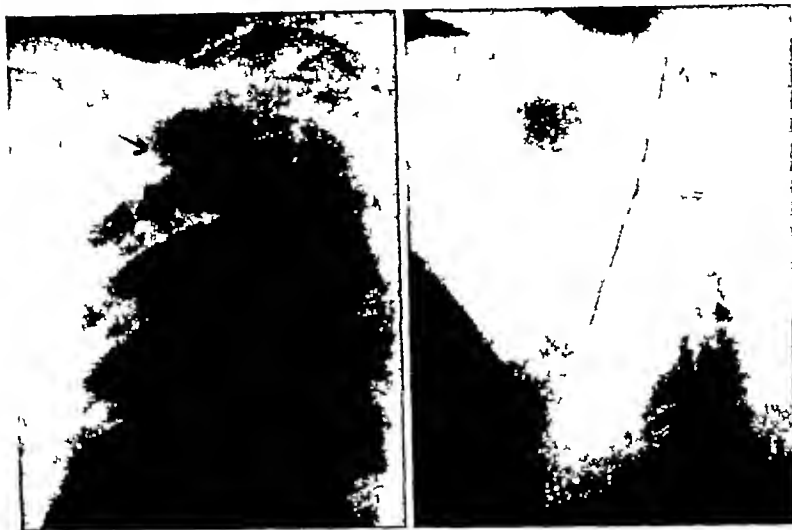


Fig 15 Unilateral single negative pressure cavity a, left, Before treatment, b, after three stage thoracoplasty, cavity closed

months or more. A total of 27 positive pressure cavities have been treated with transthoracic intracavitary drainage, 15 of which are still under treatment, and the end-result has not been considered although 5 have converted their sputum and 6 have a negative catheter drainage. Of the 11 patients treated for 3 months or more, 9 have converted their sputum, in the 2 others the positive sputum is considered to be from a source other than the cavity under aspiration. Seven cavities have been closed, including complete healing of the fistula tract and disappearance of tubercle bacilli from the sputum. The 4 remaining have been reduced in size to a fistulous tract. There are no tubercle bacilli in the discharge. We have treated 30 nontension cavities by thoracoplasty alone. Five of these have been under treatment for less than 3 months and 3 have converted their sputum. It is too early to consider whether or not the cavities are closed. Of the 25 remaining cases which have been under treatment for 3 months or more, 24 have definitely converted their sputum and closed their cavities. In the twenty-fifth case the positive sputum is known to be coming from a lesion on the contralateral side. Thus, by estimating intracavitary pressure before instituting collapse therapy and using suction drainage for tension cavities and thoracoplasty for negative or atmospheric cavities, the percentage of closure of tension cavities is 67 per cent, whereas that for nontension pressure cavities is 91 per cent.

Perhaps the most striking feature of transthoracic intracavitary drainage of a tension cav-

ity, aside from its rapid shrinkage, is the rather remarkable improvement in the patient's general condition. In all of our cases except one, shortly after the commencement of drainage there was a decrease in pulse rate, improvement in color and appetite, and a general decrease in signs of toxemia. Over a period of weeks there was usually a steady increase in weight.

Complications We have had no true complications which resulted from introduction of a catheter into the cavity.

Residual cavities There were 5 residual cavities, 4 unilateral and 1 bilateral. Of these, 3 were needled and were found to have highly positive pressures. Of the unilateral cases, 4 in number, 2 cavities were packed extrapleurally with excellent results—conversion of the sputum and closure of the cavity. Two had transthoracic intracavitary drainage and are still under treatment, both sputum and catheter drainage remain positive. In the case of bilateral residual cavities, a catheter was introduced into the cavity on one side, continuous suction drainage was maintained for a period of 4 weeks, at the end of which time the patient died of a psychosis.

Deaths There have been no deaths immediate or postoperative from transthoracic intracavitary drainage. In this series we have had 5 deaths—1 has been described under residual cavities. Of the 4 remaining, 3 patients had bilateral disease, 2 of these had bilateral cavitations. One died of kidney failure secondary to a blood transfusion reaction. This patient had received cavity drain-

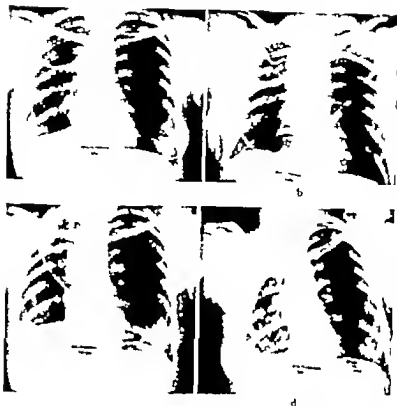


Fig. 6. Unilateral single tension cavity treated successfully by combination of cavity drainage and selective thoracoplasty (Case 5). a, Before treatment; b, first chest concerned, catheter in place; c, 6 weeks later cavity almost disappeared; d, 1 year later cavity closed.

age with subsequent closure of the cavity drained. The intracavitary drainage was supplemented by a thoracoplasty. At autopsy there was no macroscopic or microscopic evidence of the original cavity. The second patient, case 1b/lateral pical cavitation, positive cavity on the right and a negative cavity on the left, received a five rib upper stage thoracoplasty on the left and transthoracic intracavitary drainage on the right, followed by a three rib thoracoplasty. Her sputum converted and both cavities were closed. Her death was accidental and occurred due to the aspiration of a foreign body. At autopsy both cavities are shown to be well healed by scar tissue (see x-ray and photograph of specimen, Case 6). The third death occurred 3 weeks after an anterior stage thoracoplasty performed on a patient who had previously had seven rib thoracoplasty on the opposite side. The death appeared to be due to circulatory failure. No autopsy was obtained. The one death perhaps associated with trans-

thoracic intracavitary suction drainage occurred during the process of treatment. A right sided tension pical cavity was drained. Six weeks after intracavitary suction drainage had been commenced, in spite of the fact that the cavity remarkably reduced in size, the catheter drainage was negative for tubercle bacilli and the sputum had converted, the patient developed tuberculous meningitis and died within 2 weeks. At autopsy the cavity was found to be reduced in size, the walls of the cavity had been cleansed of diseased tissue, and were smooth and glistening in appearance. Sections taken from the wall of the cavity failed to reveal areas of necrosis and showed an unusual pericavitary hyperemia (see Fig. 14).

CASE REPORT

The following case histories are illustrative of the various types of tension and nontension cavities which have been cared for under our supervision.



Fig 17 Unilateral tension cavity with honeycombing on same side (Case 3)
Drainage of tension cavity preceded by anterior stage and followed by 3 stage posterior thoracoplasty

CASE 1 Unilateral disease, atmospheric or nontension single cavity, of which there were 8. Male, aged 27 years, was admitted to Grace Dart Home Hospital, February 7, 1942. Hospital No 3688. Onset of disease, November, 1941. Diagnosis on admission moderately advanced tuberculosis of the right lung with giant cavity measuring 5 by 6 centimeters and showing a fluid level. The sputum was Gaffky III, vital capacity 3.7 liters. On March 17, 1942, the cavity was needled and the pressures were found to be minus five minus three. No evidence was found of a positive pressure cavity. On April 2, 1942, a three stage eight rib thoracoplasty of the right side was commenced and finished on May 5, 1942. The sputum became Gaffky I after the first stage and negative following the second, it has continued to be negative ever since. November 12, 1942, a tomogram x ray showed no evidence of a residual cavity (Fig 15).

CASE 2 Single female, aged 26 years, was admitted to Grace Dart Home Hospital on September 10, 1940. Onset of disease in June, 1937. Right pneumothorax was commenced in February, 1938 but was discontinued after 2

months. Diagnosis on admission right sided pulmonary tuberculosis with giant cavity measuring 11 by 8 centimeters in the upper half of the lung, with scattered shadow in the lower half and above the second rib anteriorly, on the left side. Sputum was Gaffky V. On January 22, 1941, intracavitary pressure readings were taken and found to be minus one, plus five. Transthoracic intracavitary suction drainage was commenced immediately. The sputum became negative 1 week after suction was started and the catheter specimen became negative on May 10, 1941. The cavity quickly reduced in size and by July, 1941, was no longer to be seen. The tube was removed and the sinus closed almost immediately afterward. In November, 1941, a tomogram showed the cavity to be open, irregularly shaped and about 1 centimeter in diameter. A two stage upper thoracoplasty was started on November 25, and completed on December 17. Repeated x ray and sputum examinations have failed to show any further activity of the disease. At the present time the patient is working. The cavity has remained closed and the sputum negative (Fig 16).

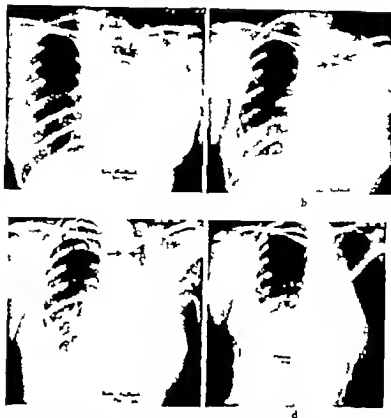


Fig. 4. Bilateral disease with single negative pressure cavity (Case 4). a, Before treatment; b, after first stage thoracoplasty cavity markedly reduced in size; c, after second stage, cavity is vertical; d, after third stage cavity closed.

CASE 3. Unilateral disease, honeycomb cavity with large tension cavity, of which there are 3. Male, aged 33 years, as admitted to the Grace Dart House Hospital, July 5, 1941. Onset of disease was in September, 1940. Diagnosis on advanced pulmonary tuberculosis, right lung with several cavitations in the apex. The sputum showed Gaffky VI. There was scarred torax and an inefficient pneumothorax on the right side which as allowed slowly to absorb. On January 2, 1942, it had completely disappeared, revealing cavity in the right apex of about 10 by 4 centimeters, and a second cavity of 3 by 2 centimeters in the periphery of the right lung field. The two cavities did not communicate (Fig. 7). On January 20, 1942, the intracavitary pressures were obtained by needling and found to be zero, plus four. An anterior stage thoracoplasty was performed and approximately 3 months later on April 2, transthoracic intracavitary suction drainage was commenced. At that time sputum was Gaffky IV and intracavitary pressures were zero, plus three, on quiet respiration. The cavity became progressively smaller, the general condition of the patient markedly improved, and on June 1, 1942, pleuremic crush was done on the right side and cavity drainage which was positive, became negative consistently on May 20, 1942. Sputum turned negative on October 3, 1942. A tomogram taken November 2, 1942, showed almost complete con-

solidation of the remaining portions of the right lung field with the draining tube in place. The cavity was completely collapsed around the catheter. There was still some residual cavitation in the upper and middle lobes but as separate from the cavity undergoing drainage. Prior stage thoracoplasty was commenced February 3, 1941, with drainage tube still in place. There was very little discharge from the sinus and it closed within weeks after its removal. Tomogram on March 25, 1941, failed to show evidence of the residual drained cavity but suggested multiple emphysemas or tuberculous bronchiectases throughout the right lung. A second stage thoracoplasty was done on April 4, 1942, third stage 3 weeks later. Patient is doing well and about to be discharged. Cavity closed (tomogram).

CASE 4. Bilateral disease, with single cavity of which there are 2 cases. Mrs. V. C., aged 26 years, as admitted to Grace Dart House Hospital, May 20, 1941. Onset of disease, September, 1940. A left pneumothorax was commenced in that month. Diagnosis on advanced bilateral pulmonary tuberculosis with pneumothorax and adhesions at left with fluid. The vital capacity was 600 cubic centimeters and the sputum showed Gaffky V. The left pneumothorax was abandoned and the lung, as completely expanded by January, 1942. A cavity of 13 by 5 centimeters was seen, which showed pressures of tension five

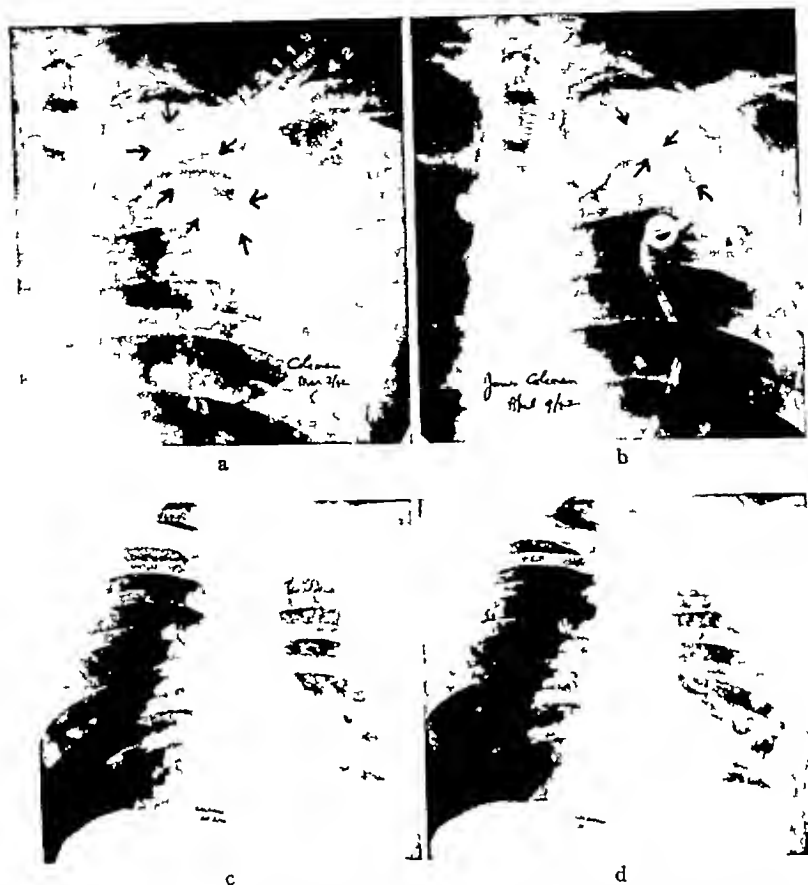


Fig 19 Bilateral disease, single tension cavity treated by intracavitary suction drainage and thoracoplasty (Case 5) a and b, Catheter in cavity, c, cavity closed—suction discontinued, d, after upper stage thoracoplasty

minus three upon needling. On January 26, 1942, an upper stage left sided thoracoplasty was performed. Note in the x ray reproduction how the cavity has become considerably smaller, but elongated, measuring 2.5 by 6 centimeters (Fig 18). A second stage with removal of 4th, 5th, and 6th ribs was conducted on February 9, 1942. Sputum became negative on February 21, 1942. The cavity had collapsed to 6 centimeters by 8 millimeters. On February 27 the 7th and 8th ribs were removed. X ray pictures taken after this stage showed no cavity. Tomogram, August 13, 1942, showed no evidence of residual cavity. Sputum has been negative since operation.

CASE 5 Bilateral disease, tension cavity. Ten similar cases have been treated. Hospital No 3531, male, aged 32 years, was admitted to Grace Dart Home Hospital, January 9, 1941. Onset of disease, September, 1940. A left pneumothorax was induced in January, 1941. On admission, diagnosis was bilateral pulmonary tuberculosis, far advanced. Sputum was Gaffky III and there was an inefficient left sided pneumothorax. Vital capacity was 1.8 liters. The pneumothorax was abandoned May 10, 1941. Needling of the cavity was attempted, but a free pleural space was encountered. Blood was injected into

the pleural space which did not obliterate until August, 1941. Intracavitary suction drainage was commenced on March 11, 1942. At that time pressures were plus three, plus nine. The discharge which at the beginning was thick slowly became thin. Suction pressure was started with 2 centimeters of water and by July 19, 1942, had been increased to 3 centimeters of mercury. On April 24, 1943, a left phrenic crush was done to check a slight hemoptysis from a second cavity nearby. The cavity reduced greatly in size and the amount of discharge became less. August, 1942, showed that the cavity had been reduced to the size of a tube but had not quite completely disappeared. On October 2, 1942, and on October 23, 1942, a 6 rib upper stage posterior thoracoplasty was performed. The catheter was withdrawn before the first stage, the sinus is now closed. The cavity which was drained by transthoracic intracavitary suction drainage in April, 1943, was shown to be closed, there was, however, a small residual cavity below the original cavity treated (Fig 19).

CASE 6 Bilateral disease, tension and nontension cavities on opposite sides. Hospital No 3300, female, aged 34 years, was admitted to Grace Dart Home Hospital on May 16, 1939. Onset, left sided pleurisy in 1926, right



b



d



f

Fig. 29. Bilateral apical cavities (Case 6). Apical cavity right, subcutaneous cavity left. a, Before treatment; b, right transcutaneous surface drainage; c, disappearance of cavity left after stage 3 rib thoracoplasty; d, thoracoplasty specimen showing catheter in sinus tract going through chest wall. It tip buried in scar tissue; S the R, 1st rib; C cartilage of second rib; P obliterated pleura; ST scar tissue; e, obliteration of draining bronchus (serial section of specimen d, high power magnification); f, macroscopic cavity left apex, surrounded by scar tissue; no evidence of bronchus in serial section (specimen d).

aided pleural effusion in 1937. Acute onset of present disease in 1937 with polyarthralgia, erythema nodosum, expectoration, night sweats, blood tinged sputum, fever and chills. Diagnosis on admission bilateral pulmonary tuberculosis with cavity about 4 centimeters in diameter

in the right and large cavity at the left apex. Total capacity at 8 liters. July 30, pneumothorax attempted bilaterally and failed. On March 2, at the right cavity was needled and found to have positive pressure. Transthoracic intracavitary drainage was com-

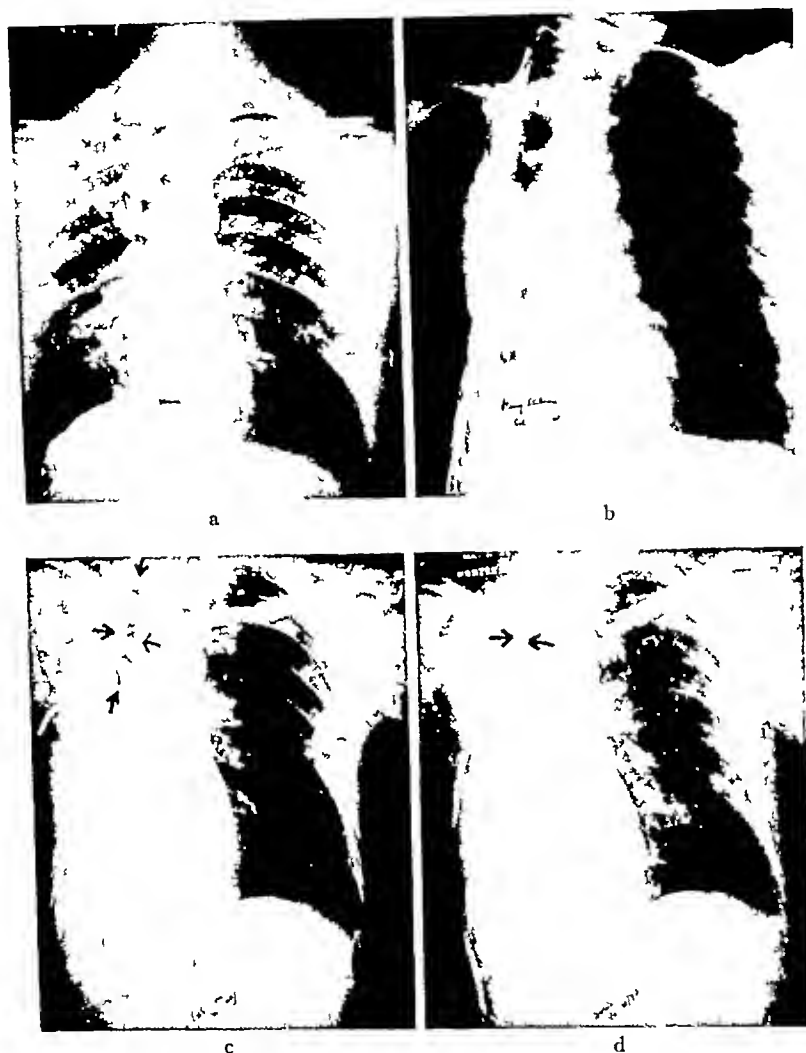


Fig 21 Residual tension cavity, treated by intracavitary suction drainage (Case 6) a, Giant cavity, b, multiple stage thoracoplasty, failing to collapse cavity, c, catheter in residual cavity d, reduction in cavity size

menaced and by September 12, 1941, catheter specimen became negative but sputum always remained positive, Gaffky IV or V, apparently coming from the other side. A tomogram of the right apex in January, 1942, showed that the cavity was reduced practically to the size of a tube. The cavity on the left side was still present. In April, 1942, the cavity in the left apex was needled and found to have negative pressures. An upper stage, left sided thoracoplasty was commenced in April and concluded by May 20 with removal of the upper 5 ribs. Sputum became negative in October, 1942, and stayed negative. On March 10, 1943, with a drainage catheter still in position the upper three ribs were removed on the right side posteriorly. Shortly after the operation, by accident, the patient aspirated in a great amount of fluid into her lungs while

vomiting. The vomitus was removed immediately and oxygen was given, the patient recovered but died 2 weeks later due to an aspiration bronchopneumonia. Autopsy showed a complete consolidation of the right apex with complete obstruction of the draining bronchus. The lower parts of both lungs were atelectatic and there was evidence of blocking of the lower bronchi. No active lesion was seen in the entire lung on either side. At the left apex, there was no macroscopic evidence of cavity or disease. There was only scarred tissue. (See Fig 20 x ray picture and photographs of pathological specimens.)

CASE 7 Residual cavity of which we have had 3 treated by transthoracic intracavitary suction drainage. H. S., male, 30 years of age, was admitted to the Grace Dart Home Hospital September 16, 1941. History of onset,

of thoracoplasty upper eight ribs posterior on the right side in 1930 followed by pneumectomy in 1930. Condition on admission, apertus Galky III general condition good. Diagnosis on admission, giant residual apical cavity on the right, 11th old thoracoplasty. On October 5, 1934, partial Schede operation as performed and the parietal pleura over the cavity as exposed. The bases of the cavity could be felt on exploratory needle as inverted, and pressure readings of plus one plus eleven are obtained. An extrapleural pack as placed into to compress the cavity against the eribone the pack as changed to ice and finally took out the cavity. A rubber catheter as placed within the cavity and suction drainage instituted. There has been improvement, a diminution of the size of the cavity since the commencement of tertiary suction drainage and great reduction in the amount of sputum. The sputum and better drainage are still present. (See)

ANALYSIS OF STUDY

Type of patient. Comparison (result obtained by the workers using different techniques and treating patients having a different type of disease is somewhat difficult. Very few if any workers present detailed picture of the extent and stage of the disease of the patient under treatment. Differences in types of disease may explain in part some of the differences in result. For example Maxwell and Kohnstamm (10) report that two-thirds of their drainage cases show free pleural space. In our own experience of 70 cases, we encountered 4 free pleural spaces. This comparatively low incidence may be due to the fact that at the Grace Dart Home Hospital pneumothorax is always attempted first as a collapse measure; other methods of collapse are considered only when pneumothorax is inefficient. In studying the literature and examining reports of other workers, we have been impressed by the few who have studied intracavitary pressures. This failure to appreciate the importance of the tension cavity first outlined by Coryllos (6, 7) may account for the great number of failures with transthoracic or intracavitary drainage which are reported by so many workers. It would seem that by far the great majority, including Monakki and his associates, for the most part drained any large cavity regardless of the intracavitary pressure conditions. We have had no experience with the drainage of a transphrenic or negative pressure cavities. Our results with thoracoplasty in this type of cavity have been so satisfactory that we have hesitated to attempt a new procedure under conditions with which we are not familiar. We find it difficult to understand the reasoning of Maxwell and Kohnstamm, who are of the opinion that there is no constant relationship between the intracavitary pressure and the response of cavities to drainage. This view is in great variance with

many workers such as Coryllos, Flower, Vineberg and Kunstler and others.

Diagnosis of types of cavities. There are those who maintain that a thickened x-ray shadow surrounding a cavity is indicative of a rigid cavity wall. There are others, however, who maintain that a thickened cavity wall due to fibrosis is extremely rare; that it is more commonly caused by atelectasis and exudation which is reversible according to the views of Monakki. A study has stated previously that an x-ray diagnosis of tension cavity cannot be made with accuracy. In cavity examination determine the presence of fibrosis as against atelectasis and exudate processes. We agree with Monakki and his co-workers that most, if not all, cavities, if properly treated, have walls which are sufficiently flexible to permit of their collapse.

Technique of transthoracic cavity suction drainage. (1) Pressure readings. (2) Intracavitary drainage. (3) Suction. There are reported in the literature a great number of complications and unfortunate accidents following cavity drainage. For example in 330 cases treated by Monakki and quoted by Kujala there was 1 death at the time of puncture, 1 hemorrhage after puncture of the cavity, 1 septic empyema, 3 tuberculous empyemas, 3 pleural effusions, one quiescent pneumothorax. Another group of others, Goldman, Bran and Ackerman report that in 15 cases, with a total of 20 cavities, there were deaths from tension pneumothorax and empyema and 1 death from tuberculous pericarditis. Likewise Davidson reported 8 cases of intracavitary drainage of the 8, died within 6 days of onset of infection following thoracoplasty; 1 died several weeks following insertion of the catheter from hemorrhage and patient had severe hemorrhage of an intercostal vessel requiring that the suction drainage be discontinued. It might be well to point out here that Davidson made use of a metal cannula which was constantly kept within the cavity and was probably responsible for the hemorrhage. In 50 instances of cavity needling there has not been one severe hemorrhage or contamination of pleural space by embolism, or pericardial tract. With regard to transthoracic intracavitary drainage there has been no case of hemorrhage, empyema, or embolism, tension pneumothorax. In a total of 27 cases. The technique worked out by the workers should obviate any of the above complications. In cavity needling the needle goes through the pleura (the exact point) which is known to be adherent and not to be a free pleural space. The exploratory needle is inserted directly through the initial pneumothorax

TABLE II

Treatment	No of cases	Cavity pressure		Sputum converted	Catheter drainage negative	Cavity closed	Cavity reduced to fistulous tract	Percentages of cavity closure
		Positive	Negative					
Intracavitary drainage with or without thoracoplasty— Under 3 months	9	9	—	3	3	*	3	*
Over 3 months	15	15	—	10**	14	10	3	67 ✓
Thoracoplasty alone— Under 3 months	6		6	4		*		*
Over 3 months	24		24	23†		22		91
Totals	54	24	30	40	17			

*Not considered

**In 4 cases the positive sputum is coming from another source

†Positive sputum is coming from disease on the contralateral side

needle Prior to intracavitary drainage we are most careful to be certain that there is a wide area of pleural symphysis surrounding the prospective point of puncture Hemorrhage and air embolism are avoided by needling carefully around the original needle shaft in order to pick up any blood vessels which might have been missed by the exploring needle and which would not be missed by an entering cannula many sizes larger

We try to avoid air embolism in two ways one is the use of the electrocoagulating current which is applied to the shaft of the exploring needle and subsequently to each cannula as it is inserted through the chest wall into the cavity of the lung, the other is the use of a saline filled syringe, when an exploring needle is used to enter a cavity lumen

Suction The suction first advocated, and we believe still advocated, by the Monaldi school is that of intermittent two bottle type of suction, in fact, Monaldi apparently was adverse to using continuous and strong suction This view is also held by many others and may account for some of the rather indifferent results of cavity closure which have been obtained by intracavitary suction A tension cavity is largely of mechanical origin and the cure must be partly on a mechanical basis The amount of air which will enter a cavity and be trapped therein will depend upon the diameter of the valvular bronchus A two bottle system, such as used by many, may have sufficient aspirating power to take care of small valvular bronchi, but will certainly not be sufficiently powerful to maintain atmospheric or slightly negative pressures in a positive pressure cavity where there is a large bronchus with a valvular mechanism For this reason, we employ continuous strong water suction This has been criticized as being harmful, such criticism is not valid A pressure check valve is inserted in the cir-

cuit and can be set so as to control pressures as low as a few centimeters of water to 6 or 8 centimeters of mercury When the suction pump is located in the cellar, such as it is in the Grace Dart Home Hospital, the objection with regard to noise no longer holds

CONCLUSION

It will be noted from Table II that in a total of 54 cases, 24 of which had tension cavities treated by transthoracic intracavitary drainage and supplemented by thoracoplasty, there was a 67 per cent closure of the cavities Of the 30 nontension cavities, treated by thoracoplasty alone, those which were treated for more than 3 months showed a 91 per cent closure of the cavities In other institutions in which thoracoplasties have been done over a period of years, a certain percentage of cavities have failed to close regardless of how extensive was the thoracoplasty collapse In our series there are 4 residual cavities from thoracoplasties which had been done elsewhere and transferred to our institution, and 1 which was operated upon in our own institution prior to our needling of cavities We were able to show positive pressures in 3 of the 5 residual cavity cases which we feel is somewhat presumptive evidence that perhaps the residual cavity was originally a tension cavity prior to its collapse by a thoracoplasty In conclusion we suggest that a rational logical basis for treating tuberculous pulmonary cavities be established, and that all methods of collapse therapy be used according to the type of case and cavity Cavities having positive pressure or so called tension cavities should first be reduced in size by transthoracic intracavitary drainage In so doing large cavities can be healed when cavity drainage is supplemented by thoracoplasty If the cavity is brought down to the size of a catheter the extent of thoracoplasty

needed rarely exceeds more than five ribs, thus it is possible to close large tension cavities with a minimum destruction of normal lung parenchyma. In those large apical cavities in which the cavity has reached the parietal pleura, a relaxing anterior stage thoracoplasty can be done to advantage prior to the transthoracic intracavitary drainage procedure. The aim of every thoracic surgeon should be to try to conserve healthy pulmonary tissue. The closure of a large cavity at the expense of an entire lung is a most costly procedure to the patient's respiratory economy and should be avoided whenever possible.

SUMMARY

1. A large percentage of pulmonary tuberculous cavities are "tension cavities" and rarely close with thoracoplasty.

2. Some residual cavities are "tension cavities" which are unaffected by thoracoplasty.

3. The detection of tension cavities can be made only by needling of the cavity and recording of the intracavitary pressures.

4. Transthoracic intracavitary suction drainage is recommended only for use in "tension cavities."

5. A new technique and instruments for needling and draining tension cavities are described.

6. In 150 instances, cavities were needled and 27 cavities were drained without a single complication of hemorrhage, pleural empyema, spontaneous pneumothorax, or air embolism.

7. Intracavitary suction drainage will reduce large "tension cavities" to the size of a catheter to obtain permanent closure a partial thoracoplasty is essential.

8. In giant positive pressure cavities anterior stage thoracoplasty precedes suction drainage and the latter is followed by posterior stage thoracoplasty.

9. Negative pressure giant cavities close readily with thoracoplasty.

a. By the use of a combination of transthoracic intracavitary suction drainage and thoracoplasty in the treatment of "tension cavities" the ideal of collapse therapy is attained, namely a maximum collapse of diseased areas with a minimum of damage to normal lung parenchyma.

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FURTHER OBSERVATIONS ON SURGERY OF THE LARGE ARTERIES

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I A NEW PRINCIPLE IN THE LIGATION OF LARGE VESSELS

CERTAIN anatomical features of the brachial and superficial femoral vessels contribute to the greater incidence of gangrene following ligation of the brachial and popliteal vessels. Due to the paucity of large branches in the mid-arm, ligation of the distal part of the brachial artery just proximal to the inferior collateral ulnar artery introduces a large, more or less stagnant reservoir or blind segment into the circulatory bed. The purposeless expansion of such a blind segment with each pulse beat serves to absorb or dissipate the force of each arterial pulsation, thus reducing materially the effectiveness of such pulsation in opening up larger and more adequate collateral branches such as the superior ulnar collateral artery.

Similar conditions prevail following ligation of the distal part of the superficial femoral artery or of the popliteal artery. Ligation of the superficial femoral artery just beyond the emergence of the deep femoral artery rarely precipitates gangrene due to the adequacy of the collateral circulation provided by the opening up or expansion of the deep femoral artery and its branches. However, as ligation of the superficial femoral artery is performed farther and farther distal to the emergence of this deep femoral branch, there is introduced into the circulatory bed by such ligation a longer and longer blind or stagnant segment practically devoid of any significant branches. Such a blind segment is capable of absorbing the force of each pulsation and dissipating its effectiveness in expanding the deep femoral artery adequately enough to prevent gangrene. Anatomically conditions remain the same, the deep femoral artery is there capable of expansion,

but in addition there is a stagnant segment between the deep femoral branch and the ligation which absorbs the force so necessary for the opening up and expansion of the collateral vessels.

As evidence of the possible impairment to the development of collateral circulation imposed by such a blind segment, the following experiments were carried out.

Experiment 1 Under intravenous nembutal anesthesia the external iliac and femoral vessels of a 12 kilogram animal (dog) were exposed. The deep femoral branch was cannulated (Figs 1 and 2) and connected with a mercury manometer which recorded the blood pressure on a revolving kymograph. Several small branches of the femoral artery were ligated, thus providing a branchless segment *PD* about 14 centimeters long. The mean arterial pressure as recorded in the deep femoral artery was found to be 100 millimeters of mercury. Clamping the femoral artery at *P* (Fig 1) raised the pressure to 106 millimeters of mercury, but on clamping the artery at *P* (Fig 2) thus eliminating the blind stagnant segment between *P* and *D*, the pressure rose to 112 millimeters of mercury (Fig 3). These pressure changes are all the more significant because of the obvious limitations of such an apparatus—due to the lag and inertia of its various parts—for recording accurately pressure changes of such small degree.

The experiment was repeated on several occasions, and confirmatory evidence obtained, although not always were the pressure changes as pronounced.

Experiment 2 A cannula was introduced into the left subclavian artery, and a segment of the thoracic aorta about 15 centimeters long isolated by division of its intercostal branches. Clamping the aorta just beyond the cannulated subclavian artery caused a rise in mean arterial pressure from 66 millimeters of mercury to 148 millimeters of mercury, but clamp-

The opinions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large. Dr Holman was formerly Chief Surgeon, Mare Island Naval Hospital.



Fig. 1. Experiment 2. Exposure of femoral artery in cat. Cannulization of the deep femoral branch for recording arterial pressure. When the clamp was applied at *D*, arterial pressure rose from 80 to 90 millimeters of mercury.



Fig. 2. Experiment 3. When femoral artery was clamped at *P*, thus eliminating the blood segment *PD*, arterial pressure was increased from 80 to 134 millimeters of mercury, thus doubling the increase in pressure produced by clamping the artery at *D*.

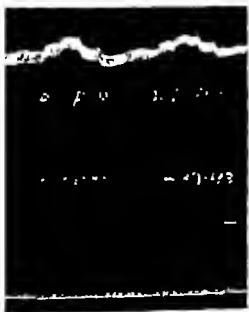


Fig. 3. Experiment 1. Kymographic record of increase and pressure (—) on clamping femoral artery at *D* and (---) *P* with decrease in pressure on removing clamp at *D* and further decrease on removing clamp at *P* (see and).

ling the thoracic aorta 15 centimeters beyond the subclavian artery caused a rise from 66 millimeters of mercury to 134 millimeters of mercury thus demonstrating again a dispersion and loss of arterial pressure in the purposeless distention of the blind segment of the aorta.

The problem was approached from a second point of view.

Experiment 3. The iliac and femoral vessels in a 15 kilogram animal were isolated for about 20 centimeters. The first large distal branch, namely the deep femoral artery was cannulated for recording blood pressure. The mean arterial pressure was found to be 140 millimeters of mercury. A permanent ligature was applied at *P* (Fig. 4) resulting in an immediate drop in pressure in the cannulated artery to 80 millimeters of mercury which represented the arterial pressure in the collateral circulation. A clamp was applied at *D* (Fig. 5) resulting in an immediate rise in pressure from 80 millimeters of mercury to 90 millimeters of mercury (Fig. 6). It is apparent that a significant part of the collateral arterial pressure was dispersed or dissipated in purposeless disten-

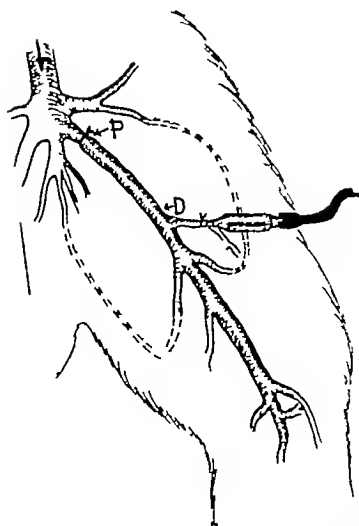


Fig 4 Experiment 3 Iliac and femoral arteries isolated and cannula introduced into deep femoral branch for recording arterial pressure Application of a permanent ligature at *P* reduced the arterial pressure at *D* to 80 millimeters of mercury

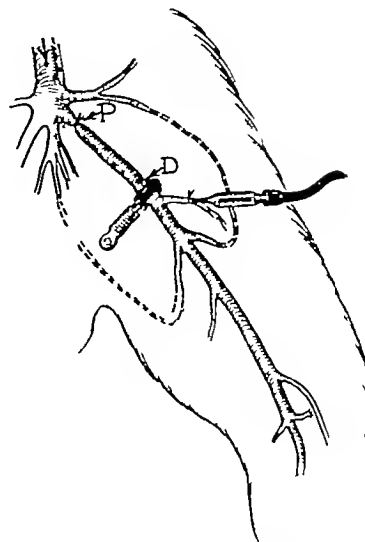


Fig 5 Experiment 3 The application of a clamp on the femoral artery at *D* resulted in an increase in arterial pressure from 80 to 90 millimeters of mercury by eliminating the loss of pressure through purposeless distention of the blind segment *DP*

tion of the blind or stagnant segment *PD*. Elimination of this blind segment from the circulatory bed resulted in increasing materially the pressure available from the collateral circulation for filling and distending the arterial bed beyond the ligated artery. Considering the mechanical inefficiency of the apparatus for recording blood pressure—due to lag and inertia—these differences in pressure were probably even greater than were recorded on the kymograph.

We may deduce from these experimental observations

- 1 That a large artery should be ligated preferably just distal to a large collateral branch so that the full force of the arterial pulsation in the main ligated artery is directed into this large branch. A long segment with small inadequate branches lying between the ligature and the first large branch must be avoided in order that arterial pulsation is not dissipated in purposeless distention of this segment and of its small inadequate branches.
- 2 That the distal ligature of a divided artery should be placed just proximal to a large collateral branch. To have a blind segment between the ligature and this collateral branch is

inviting dispersion of arterial pulsation in the purposeless distention of this segment when such arterial pressure were better directed to the distention of distal vessels.

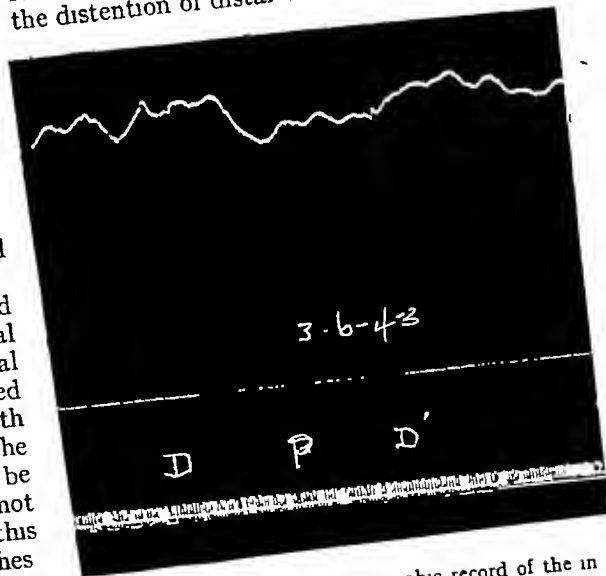


Fig 6 Experiment 3 Kymographic record of the increase in collateral arterial pressure by application of clamp at *D* and *D'* (see Figs. 4 and 5), and reduction in pressure when the segment *DP* was open

As an example of the application of these principles, the following clinical experience is presented

CASE. G. W. S. a 39 year old shipfitter was struck by a sharp sheet of steel on the medial aspect of the left upper arm on August 20, 1912. He noted some local swelling and discoloration just above the elbow but this disappeared, to be followed about 4 weeks later by the development of a small pulsating lump at the site of injury. This gradually increased in size and after another month had passed, he experienced paresthesias in the peripheral distribution of the median and ulnar nerves. In the meantime he was transferred to Alaska, where he was practically incapacitated by the cold weather which made his left hand feel numb and much colder than the right. On November 2, 1912, there was described in his service record "pulsating tumor about 3 centimeters in diameter lying just above the medial epicondyle of the left humerus. Pressure on the brachial artery above the tumor caused it to disappear. The Kahn test was negative."

He was admitted to Mare Island Naval Hospital on January 27, 1913, with the conditions described unchanged (Fig. 7). Pressure above the expansile tumor caused the tumor and the radial pulse to disappear, accompanied by bluish discoloration and a feeling of numbness and coldness of the hand. There was no thrill nor bruit over the tumor. Blood pressure in the right brachial artery was 105/60, in the left brachial artery 105/81.

Because of the obvious evidence of impaired circulation in the hand on compressing the brachial artery, the patient was instructed to spend 5 minutes of every hour during the day in shutting off the brachial artery above the aneurysm by compressing the vessel against the humerus. Gradually the paresthesias disappeared and he was operated upon on February 15. Under local anesthesia, the brachial artery was exposed proximal to the pulsating mass by displacing the biceps muscle laterally and the overlying median nerve medially. The aneurysmal sac was fusiform dilatation without connection with the brachial venae comites which coursed along both sides of the aneurysm. They were displaced by sharp dissection and not tied. The brachial artery was isolated proximal to the dilatation for about 7 centimeters, two small inconsequential branches being ligated. Just beyond the lower border of the teres major muscle a large posterolateral branch, the superior ulnar collateral, was encountered, and a clamp was placed on the artery just distal to it. Despite this proximal closure of the artery pulsation in the sac could still be observed, indicating an effective collateral circulation (Heule-Coenen phenomenon).

The sac was isolated and distally it was found that a large branch, the lower ulnar collateral, left the vessel just beyond the sac. The brachial artery was tied with silk just proximal to this branch, and the aneurysm and about 6 centimeters of the normal

proximal brachial artery were excised. Good pulsation was observed in the distal stump. When this so called Heule-Coenen phenomenon is observed, one need have no fear as to the adequacy of the collateral circulation, and the accompanying vein or veins need not be ligated. The hand was warm and pink, and all movements were possible in the muscles of the elbow, wrist, and fingers. The proximal stump was doubly ligated with silk. Subcutaneous tissue and skin were closed with interrupted silk sutures without drainage. A flat dressing was applied, kept in place by adhesive strapping, and did not encircle the arm. Encircling bandages or adhesive must never be applied to an extremity whose main vessel has been ligated, because of the danger of closing small collateral vessels coursing through compressible muscle masses.

After the operation, the patient's hand both objectively and subjectively, felt cold for several weeks, with some slight numbness for several days, though sensations and motions were all retained, and at no time was there any suggestion of gangrene. It was obvious however that the margin of safety with reference to the adequacy of collateral circulation, was not very wide and that the loss of even a small part of the arterial pressure in the purposeless distention of a blind segment might have been disastrous.

II. THE MANAGEMENT OF ANEURYSMS OF THE UPPER THIGH

Few situations in surgery demand more deliberate, well considered action than the large pulsating aneurysmal swellings and arterio-venous fistulas of the upper thigh. Wise is the surgeon who hesitates before attacking a lesion that may engulf him and the tissues in a sea of blood thereby completely obscuring and defeating the object of the operation. The possibility of uncontrollable bleeding fraught with such embarrassment to the surgeon and such tragedy for the patient requires careful planning and special measures.

An important maxim here, and elsewhere as well, is not to incise a pulsating swelling without first having attained complete control of the normal artery above the lesion and preferably also below the lesion. A tourniquet above lesions situated in the upper thigh is usually out of the question.

Occasionally also direct attack upon a simple fusiform aneurysm is not feasible and one

must be content with ligation of the normal artery proximal to the aneurysm

The following two instructive examples of arterial lesions of the upper thigh and their management are presented

CASE 2 Ligation of superficial femoral artery for ruptured fusiform aneurysm

D K, a 77 year old farmer was admitted to Stanford Hospital on September 20, 1942. About 7 years before this admission, he had been struck in the left upper thigh by the handle of a pitchfork. A soreness for several days gave place to a tenderness which has persisted ever since. About 3 years previous to admission, a small pulsating lump about 1 inch in diameter appeared at the site of previous injury, which had recently increased rapidly in size. Two days before admission he experienced very sharp pains in the thigh followed by a marked increase in swelling and by the appearance of ecchymotic areas on the inside of the upper thigh and scrotum. Both work and sleep were impossible because of the intense pain.

Examination revealed a thin, poorly nourished man with a left thigh swollen to twice normal size. The dependent posterior soft tissues were infiltrated with blood and the skin of the thigh and left scrotum showed large areas of ecchymosis of recent origin. The swelling in the upper thigh had an expansile pulsation and a to-and-fro murmur was audible over it. The murmur was not continuous, there being a definite hiatus between the systolic and diastolic phases of the murmur. This characteristic of the murmur excluded an arteriovenous aneurysm, the bruit of which is invariably continuous. This evidence is most important. In the presence of a *continuous* bruit one would never consider simple ligation of the artery proximal to the lesion, since such a procedure in the presence of an arteriovenous fistula would most certainly lead to gangrene. Deep pressure over the common femoral artery just below Poupart's ligament stopped the expansile pulsation and the bruit, but did not alter the pulse rate, nor increase the blood pressure. Pulsation was present in both popliteal arteries, but absent in the posterior tibial and dorsalis pedis arteries on both sides. The general blood pressure was 140/90, pulse rate 110, the red cells numbered 3,000,000, white cells 7,700, and hemoglobin was 52 per cent Sahli. The Wassermann reaction was negative.

A roentgenogram of the thigh (Fig 8) revealed an astonishing calcification of both femoral vessels, with a perfect delineation of the fusiform aneurysm in the left thigh by fragmentation of the old calcified artery.

The evidences of recent hemorrhage in the thigh and scrotum and the marked anemia suggested that the fusiform arteriosclerotic aneurysm of long standing had recently broken its bounds, and that considerable bleeding into the tissues had occurred 2 days previous to admission at the time of the severe pain.

On September 25, 1942, under local anesthesia, a transverse incision was made in the anterior thigh 6 centimeters below the inguinal ligament. The artery and vein were approached through edematous blood-stained tissues. The common femoral, deep femoral, and superficial femoral arteries were identified, and it was evident that there was just enough length of normal superficial femoral artery present above the lesion to permit ligation distal to the emergence of the deep femoral branch.

The wall of the artery was quite firm and obviously infiltrated with calcium. It was isolated for about 3 centimeters. Compression of the superficial femoral artery completely stopped pulsation of the aneurysmal swelling. While the artery was compressed above the site of ligation, a braided silk ligature was applied to the collapsed vessel and tied, thus preventing fracture of its wall (Reid). A second ligature was applied distally about 2 centimeters distal to the first, and the artery divided between them. The divided ends separated about 5 millimeters through elastic contraction of the vessel walls. Transfixion sutures were applied to both ligated stumps. There was no pulsation in the distal stump. Accordingly, the superficial femoral vein was isolated and ligated but not divided. The wound was closed with interrupted silk sutures.

The wound healed satisfactorily, and at no time was there any question of the adequacy of the circulation of the foot. If such question had arisen, if the foot had become cold, pallid, and painful, repeated lumbar sympathetic interruption with novocain would have been performed to produce distal vasodilation. If gangrene still seemed imminent, the femoral artery would have been ligated just distal to the aneurysmal dilatation, thus removing from the circulatory bed the aneurysmal swelling into which the collateral arterial pressure might be dissipated and lost.

The successful outcome in this 77 year old man may be attributed to (1) ligation of the superficial femoral artery just beyond the deep femoral artery, (2) simultaneous ligation of the femoral vein, and (3) ligation and division of the artery instead of ligation in continuity. It is quite possible that ligation in continuity of this arteriosclerotic vessel would have led to rupture of its wall at site of ligation. Moreover, division of the artery is tantamount to division of the sympathetic plexus surrounding the artery, thus providing for at least temporary vasodilation beyond the site of ligation (Leriche and Werquin).

CASE 3 Excision of arteriovenous fistula between superficial femoral artery and branch of deep femoral vein

S R M, 21 years old, was admitted to the Mare Island Naval Hospital on January 4, 1943, about 1

hour after an accidental stab wound of the left thigh just below the groin. While boning beef with a stiff to-like sharp knife he had tabbed himself. The blood gushed feet out of the wound, and he promptly fainted. The bleeding soon stopped, but was followed by a marked swelling just below Poupert ligament. On admission 1 p.m. his pulse rate was 90, and blood pressure 18/75. A pulsating swelling occupied the upper part of the left thigh with a puncture wound $\frac{3}{4}$ of an inch in length at its summit. The foot and lower leg were slightly mottled and somewhat colder than the right. Pulsation in the dorsalis pedis and posterior tibial arteries was absent on the left, normally present on the right. The pulsation in the swelling was expansive and synchronous with the pulse. There was no murmur nor thrill present on admission.

At 3 p.m. a slight thrill could be felt over the medial aspect of the swelling and a continuous murmur was heard, the diastolic component being weak but present.

On January 7, there was a sudden increase in pain, accentuated with each pulsation, accompanied by an increase in the size of the swelling. During the next few days (Fig. 9) the swelling became definitely more firm, and frequent injections of morphine were necessary for pain. However the murmur seemed to become less pronounced, somewhat higher pitched, and we were encouraged to believe that the opening between the artery and vein was small and that it might close spontaneously.

On January 10 the puncture wound, which had been practically healed during all this time, reopened with the discharge of what appeared to be thin pus. His temperature was 99 degrees F. pulse rate 116 respirations 20, blood pressure 18/80.

Delay in operating up to this time had been influenced (1) by the hope that the opening between the artery and vein was small and that it would close spontaneously (2) by the obvious difficulties involved since a tourniquet could not be used and (3) by the likelihood that the arterial wound lay so near the branching of the common femoral artery that its ligation would be necessary with an accompanying serious danger of gangrene.

Now there was no alternative. An infected hematoma connected with an arterial wound would eventually lead to repeated secondary hemorrhages and death.

The operation, performed on January 1943, consisted of temporary occlusion of the common and external iliac arteries, and quadruple ligation and excision of an arteriovenous fistula between the superficial femoral artery and the first perforating branch of the deep femoral vein.

An incision was first made along the lateral border of the lower half of the left rectus muscle (Fig. 1) passing directly through the tendinous part of the external oblique, internal oblique and transversalis muscles. The peritoneum was not opened but reflected upward to expose the left common iliac artery which was easily isolated and tape ligature

applied including segment of rubber tubing (Fig. 11) about 1 centimeter in diameter to prevent injury to the arterial wall. As the external iliac artery still felt full and tense though not pulsating, this artery was also temporarily occluded just above Poupert ligament. To avoid contamination of this wound by the presumably infected hematoma of the thigh, this wound was temporarily covered and isolated from the proposed incision in the thigh.

A second 12 centimeters long incision beginning at Poupert ligament and extending distally along the line of the common femoral artery (Fig. 1) was made through tissues well infiltrated with blood. The common femoral artery was isolated and the medially lying common femoral vein identified. The anastomotic branch of the femoral nerve was displaced medially. The deep femoral artery and vein were identified emerging from the common femoral vessels about 4 centimeters beyond Poupert ligament. The superficial femoral artery as isolated for about 4 centimeters beyond the deep femoral branch where a small aneurysmal sac was encountered. When this was opened, arterial and venous blood escaped in considerable quantity. The artery was ligated above and below the sac, thus controlling the arterial bleeding. The superficial femoral vein was isolated and ligated above the sac, but it was evident that the vein which as connected with the aneurysmal sac was the first perforating branch of the deep femoral vein. The vein was ligated at its entrance into the deep femoral vein and again deep in the wound. There was no pulsation in the distal end of the divided femoral artery.

The bloodless wound was reopened and the temporary ligatures on the common iliac and external iliac arteries removed. The wound was closed with two rows of interrupted cotton sutures, approximating the divided peroneus of the internal oblique and transversalis muscles and the divided external oblique. No drainage was instituted.

The thigh wound was closed independently without drainage, with interrupted cotton sutures in the subcutaneous tissues and in the skin.

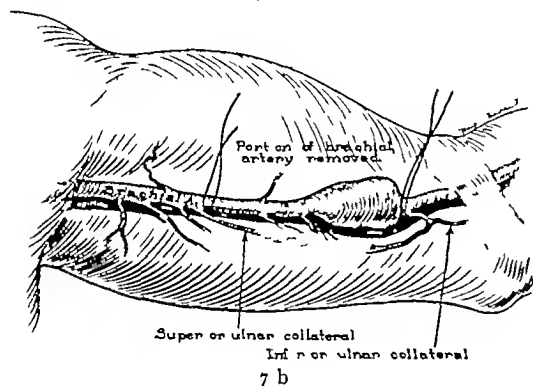
Examination of the excised specimen revealed complete severance of the artery, the small false aneurysmal sac opening into a vein. The large hematoma on the lateral aspect of the upper thigh (Fig. 1) remained stationary for about weeks when it became fluctuant. On February 6 1943, the wound was evacuated through small incision, about pint of blood clot being obtained. There was no evidence of infection. Flexion of the hip was still missed by 45 degrees and full extension at the knee was missed by 60 degrees. Rapid improvement followed the evacuation of the hematoma, and recovery was complete by May 20 (Fig. 2).

This case permitted a number of instructive observations.

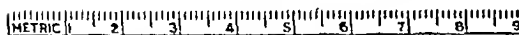
1. Complete severance of the superficial femoral artery without fatal bleeding is possible.



7 a



7 b



7 c

Fig 7 a Fusiform aneurysm of brachial artery just above elbow b, Brachial artery ligated just distal to superior collateral ulnar artery and just proximal to inferior collateral ulnar artery with excision of aneurysm and about 6 centimeters of normal artery c, Contracted specimen of excised artery and aneurysm

ble when communication with a vein is also present. Because of minimal resistance in the vein, bleeding occurs into the vein rather than to the outside through collapsed soft tissues. For this reason bleeding from a wound involving both artery and vein is more easily controlled by simple pressure than bleeding from a wound of the artery alone. Moreover, this case provided clinical confirmation of the



Fig 8 Case 2 Soft tissue roentgenogram showing the fusiform aneurysm of left femoral artery perfectly delineated by the fragmentation of the calcified arterial wall

experimentally proved fact that complete severance of an artery may be less dangerous with reference to bleeding than a tangential wound (2)

2 The persistence and recurrence of severe pain requiring frequent injections of morphine should have prompted operation at an earlier date and should have been recognized as an indication that spontaneous closure was unlikely

3 Operation upon an arterial lesion of the upper thigh may be performed with confidence even though the application of a tourniquet is not feasible by controlling hemorrhage through temporary occlusion of both the common and external iliac arteries. Occlusion of the common femoral artery alone permits collateral circulation through the hypogastric into the external iliac artery. Temporary occlusion of the external iliac artery alone permits collateral circulation through the circumflex and sciatic arteries. Therefore, to avoid embarrassing bleeding when operating upon arterial lesions of the upper thigh, both common and external iliac arteries should be temporarily occluded. The inclusion in the temporary ligature of a segment of rubber tubing about the caliber of the artery (1) prevents fracturing the walls of the artery which would invite



Fig. 2. Case 2. Photograph, day after accidental establishment of left thigh artery. Leg could not be straightened because of infiltration of tissues with blood and is held permanently flexed at hip and knee for comfort. The swelling of the thigh is as extensive, and amputation revealed the continuous limit of an arteriovenous fistula.

later trouble at site of temporary ligation and (2) enables one to remove the temporary ligation without difficulty and without injury to the artery by cutting the tape on the rubber tubing.

4. The successful result in the surgical care of this pulsating hematoma may be attributed

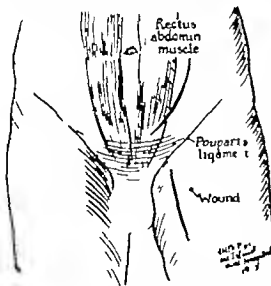


Fig. 3. Case 3. In operating upon large arterial aneurysm and arteriovenous fistula, the large fibrous sacs of the upper thigh, incisions are preferable one for the exposure of the common and external iliac arteries, and a second incision for exposure of the common and superficial femoral arteries. Division of Poupart ligament is needed.

to (a) absolute control of bleeding by temporary occlusion of the main arteries proximal to the lesion before attacking the lesion itself (b) ligation of the superficial femoral artery just distal to the deep femoral artery thus permitting an adequate collateral circulation to be established (c) simultaneous ligation of superficial femoral vein when ligation of the superficial femoral artery was found necessary.

THE RESECTION OF CLAVICLE FOR EXPOSURE OF SUBCLAVIAN AND AXILLARY VEINS WHEN OPERATING FOR ARTERIAL LESION IN THIS AREA

Success in the performance of any operation is dependent in great measure upon one's ability to control bleeding. Nowhere is this truer than in operations upon the large vessels of the neck where the hazard of bleeding are greatly accentuated. To operate successfully upon arterial lesions in this area, one must be able to expose the normal artery proximal to the arterial wound for temporary occlusion. One must also be able to occlude temporarily the proximal vein not only to control bleeding but also to avoid air embolism through accidental rents in the larger veins which in this region so frequently exhibit negative pressure during inspiration.

To insure adequate exposure of the subclavian and axillary vessels it has been found desirable to resect a considerable portion of the clavicle subperiosteally. At no time has any permanent damage resulted from such resection, since retention of the periosteum has permitted reformation of the clavicle and re-stabilization of the shoulder. Within 3 to 4 weeks, normal motion and stability have been restored.

The wide exposure of important structures permitted by resection of the clavicle has also provided greater confidence in being at all times master of the situation should any untoward event occur such as unexpected arterial bleeding tears in large veins, or injuries to the larger lymphatics. Moreover, in operating for arteriovenous fistulas, resection of the clavicle enables one to isolate and to control the artery and vein distal to the lesion as well.

CASE 4. Excision of arteriovenous fistula of left subclavian vessels.



Fig 12 a, Appearance of thigh February 13, 3 weeks after operation, showing primary healing of both wounds. Complete extension at hip still impossible due to infiltration of muscles by blood. b, Appearance of thigh April 2, 2½ months after operation showing complete extension at hip. When last seen on June 25 patient was back on full active duty, with no impairment of motion or sensation.

C. J. B., 27 years old, entered Mare Island Naval Hospital on July 25, 1942. He had been wounded by a piece of shrapnel in January, 1942, while landing his plane, the shell fragment having penetrated the left posterior axillary line and having lodged just below the midportion of the left clavicle. His left arm immediately felt numb and useless, and he was compelled to swim mainly with his right arm. He remembers bleeding profusely in the water for a brief time only. Eight days after the injury the shell fragment was removed. Within 3 weeks complete use of the arm had returned, and the wounds were all healed.

During a recent medical examination for promotion, the characteristic thrill and bruit of an arteriovenous fistula were discovered above the left clavicle. He had considered himself perfectly well, but closer questioning revealed a recent shortness of breath on climbing stairs.

On physical examination, marked pulsation was observed in the suprasternal notch which was more pronounced on the left. A continuous thrill could be felt just below the lateral third of the clavicle, but the bruit was most intense just below the center of the clavicle, suggesting that the communication lay directly posterior to the midpoint of the clavicle. There was increased precordial activity, the apex beat being visible 1 centimeter inside the nipple line. There was no demonstrable increase in cardiac area by roentgenogram.

Deep pressure over the subclavian vessels just above the medial half of the clavicle caused the pulse rate to drop from 72 to 68 and the blood pressure to rise from 126 systolic 68 diastolic to a high point of 136 systolic 90 diastolic. This retardation in pulse rate and elevation in blood pressure on closing the fistula was considered positive evidence that the opening between the artery and vein was fairly large, that it would not close spontaneously, and that increasing cardiac disability would ensue, and that operation for the elimination of the fistula was indicated to avert progressive cardiac dilatation and

eventual cardiac decompensation. Failure to act upon similar evidence in the past has resulted in serious though not fatal cardiac failure (3).

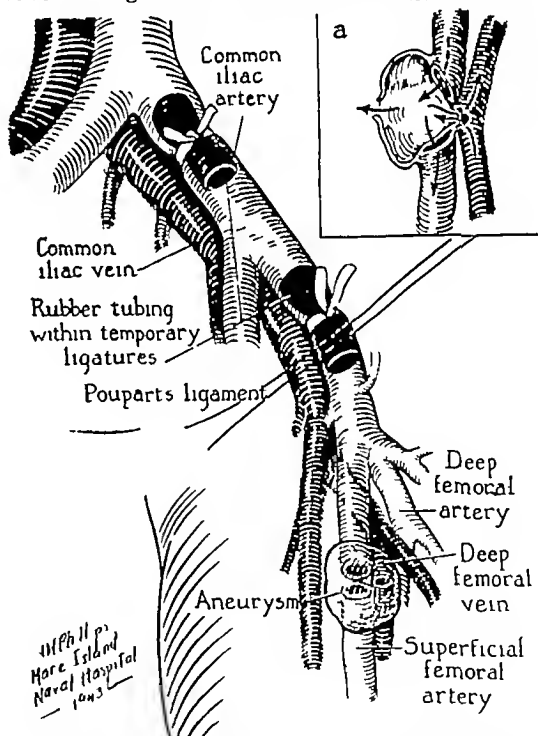


Fig 11 Case 3 Preliminary occlusion of both common and external iliac arteries by temporary tape ligatures including a segment of rubber tubing to prevent injury to the vessel wall preceded the exposure of the arterial lesion in the upper thigh. Unless both common and external iliac arteries are so occluded, collateral circulation may provide most embarrassing bleeding. A lumbar sympathectomy may be done through the upper incision if thought desirable.

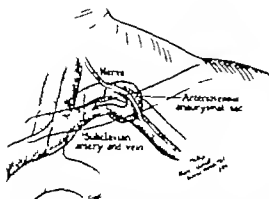


Fig. 1 Case 4 Site of arteriovenous fistula, which in each of the following ligations of subclava has artery and vein proximal to fistula and ligation of axillary artery and vein distal to fistula. Excellent exposure possible by subperiosteal resection of clavicle.

On July 3, 04 the fistula was excised. The incision was made in the direction of the skin creases directly on the clavicle. A centimeter segment of which was removed subperiosteally. The pericardium, costocoracoid ligament, and subclava muscle were divided about their midpoint and reflected to either side. A small aneurysmal sac lay between the subclava and vessels in their third part (Fig. 3). The brachial artery and vein were isolated proximal to the sac, and the axillary artery and vein were isolated distal to the sac. Both proximal and distal ends of the vessels were controlled by aneurysmal sacs, then directed free and the ends were ligated. The brachial artery was ligated in the following order: subclava artery proximal to the sac, axillary artery distal to the sac, and axillary vein proximal to the sac. The axillary vein distal to the sac. The vessels were divided and the sac and limited portion of the vessels were removed. There was no palpation in the involved distal axillary artery, but the artery felt full suggesting an adequate collateral circuit.

Following ligation of the vessels and excision of the fistula the general blood pressure rose from 100/50 to 120/80, and the pulse rate dropped from 100 to 70. On the evening of the operation the patient was comfortable, particularly the thumb felt quite numb in the hand, somewhat swollen. On the following day the hand was numb, there was cyanosis, but some motion persisted. On the 11th day following operation the motion was limited to the thumb, and by the 5th day the hand was normal subjectively and objectively. There was no radial pulse.

On August 8, the 15th postoperative day the blood pressure readings were 120/80 to 130/80, and the pulse rate was 110 beats. The patient was discharged. He left the hospital with a good radial pulse, normal functioning arm and shoulder.

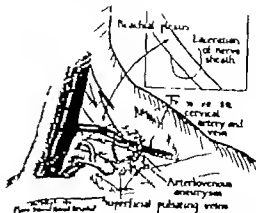


Fig. 2 Case 5 Drawing which shows the location of the arteriovenous fistula. It has been let open the transverse cervical arch. The artery proximal to the aneurysmal sac showed marked dilatation three times normal size.

Case 5. Fracture of sternum removed, but superficial cervical artery and vein.

July 3, 04, 1904. A patient with a fracture of the sternum removed, but superficial cervical artery and vein. The patient was 30 years old, male. The fracture of the sternum was 10 centimeters long, the clavicle 10 centimeters long. There was little bleeding, but partial loss of the use of the left shoulder and arm occurred immediately which has persisted to this day. The movement of the hand has been impaired.

On admission to St. Elizabeth's Hospital on July 3, 04, the small wound of entrance to the left clavicle almost invisible. There was a wound of exit, not reaching the sternum, 10 centimeters away. A sharp fragment of bone in the neck of the sternum, the point of the end of the sternum.

The superficial veins of the left neck were dilated more visible than on the right, but there was no flow. On palpation, intense thrill could be felt just below the junction of the medial and middle third of the clavicle, not loud bruit heard over the same area. Deep pressure above the middle of the clavicle obliterated the thrill and bruit, but caused an increase in blood pressure from 120/80 to 140/90. The pulse rate was 90. These rather unexpected changes were interpreted as indicating large communication between the artery and vein in the neck, which was then enlarged in this area. Subclava was exposed. However, pressure sufficient to obliterate the thrill and bruit did not affect the radial pulse, suggesting that even when the subclava artery and vein might be in contact.

The conspicuous changes in blood pressure and pulse rate were again considered. It was felt the opening between the vessels was large, perfect spontaneous closure was more difficult to find than through the small opening.

have caused an increase in total blood volume, and that the harmful effects of the fistula would probably be progressive more or less slowly through the years. The retardation in pulse rate and increase in blood pressure on closing a fistula can be explained only by this increase in total blood volume (4), and when this occurs cardiac dilatation is inevitable, and cardiac failure probable.

The atrophy and paralysis limited to the deltoid, biceps and brachialis anticus muscles indicated a limited injury to the fibers composing the brachial plexus.

On January 7, 1943, the fistula was excised. An incision was made in the creases of the skin from the suprasternal notch laterally for about 12 centimeters. In the fatty tissue underlying the platysma muscle a number of large dilated veins were encountered in which eddies of arterial blood could be seen. The medial two thirds of the clavicle was resected, subperiosteally, by division with a Gigli saw, and by disarticulation at the sternoclavicular junction. Again dilated veins were encountered, in which swirling eddies of arterial blood were seen. These dilated veins emptied into the transverse cervical vein. Several large lymph vessels were identified, one of which, because of an accidental rent, required ligation and division. The greatly dilated transverse cervical vein was divided near its entrance into the thyroid axis, revealing the underlying transverse cervical artery, pulsating strongly, about 8 millimeters in diameter, fully three times its normal size. About 6 centimeters from its origin a pulsating expansile mass about 3 centimeters in diameter was encountered as an offshoot from the cervical artery (Fig. 14). Emerging from this aneurysmal tumor was a plexus of pulsating veins, like a hemangioma, containing swirling eddies of arterial blood. These veins were ligated as was also the artery proximal and distal to the mass which was then excised. The systolic blood pressure rose from 148 to 156 following excision of the aneurysmal mass. Diastolic pressures were not recorded.

The brachial plexus was then identified posterior to the site of the aneurysm disclosing a small laceration 3 millimeters long in the midportion of the outer cord of the plexus. The laceration in the nerve sheath was extended longitudinally for several centimeters on either side. This part of the nerve was then forcibly distended with salt solution to free, if possible, the nerve fibers from investing scar tissue. Any attempt at end-to-end approximation of divided nerve fibrils was out of the question. The wound was closed by approximating the platysma muscle and skin. No drains were inserted into the wound.

An uneventful recovery followed the operation, and a slow return of muscular power is just beginning (Fig. 15).

SUMMARY

1. Experimental evidence is presented indicating the desirability of ligating a large

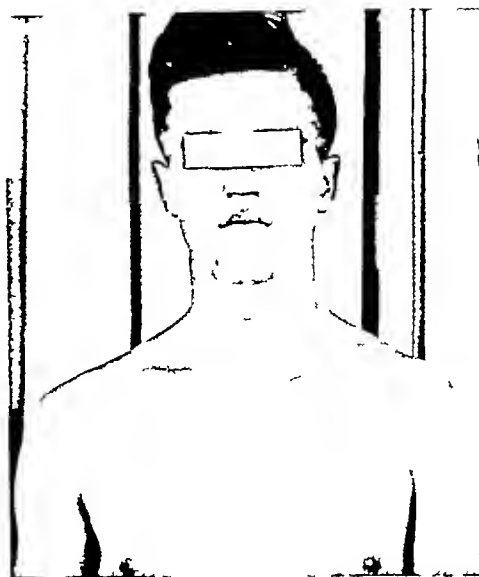


Fig. 15 Case 5. Photograph 2½ months after operation for elimination of arteriovenous fistula between transverse cervical artery and vein showing incision in direction of skin creases, loss of normal clavicular contour is due to resection of medial two-thirds of clavicle. Clavicle has partially regenerated and stability of shoulder is normal. Flattening of deltoid due to injury to brachial plexus by piece of shrapnel.

artery just beyond a large collateral vessel or branch, so that the full force of arterial pressure is directed into the expansion of this large collateral vessel and its terminal branches. If a blind segment of artery, or a segment with small inadequate branches, is left in the circulation between the large collateral vessel and the point of ligation, a significant part of the available arterial pressure is dissipated in purposeless distention of this blind segment, thus diminishing the arterial pressure which should be directed into enlarging and distending the large collateral branch and its distal bed.

2. Further experimental evidence is presented to indicate that distal ligation of a large artery, i.e., distal to the arterial lesion for which ligation is being done, should be placed just proximal to a large collateral branch. If a blind segment lies between the ligature and the collateral vessel, a part, possibly a significant part, of the arterial pressure will be absorbed or dissipated in the fruitless expansion of this blind segment, thus subtracting from

pressure that should be directed distally into peripheral branches of ligated artery.

3. It is suggested that ligation of the brachial artery should be placed preferably just distal to the superior ulnar collateral and just proximal to the inferior ulnar collateral, with excision of the intervening segment. A clinical experience is presented in which about 6 centimeters of normal brachial artery with its small insignificant branches was excised together with a fusiform aneurysm in order to meet the above conditions. It was thought that the probability of gangrene was minimized by directing the full force of the arterial pressure proximal to ligation into the superior ulnar collateral artery, thus avoiding the purposeless distention of segment of artery containing only minute branches incapable of sustaining the peripheral circulation.

4. In the thigh rarely is gangrene precipitated by ligation of the superficial femoral artery just beyond the emergence of the deep femoral artery. In cases in which necessity should normally demand ligation of the femoral artery between this site and the popliteal artery, it would seem desirable to ligate it just beyond the deep femoral artery instead to avoid leaving in the circulation a blind segment or segment with small branches capable of dissipating the arterial pressure so necessary in opening up the deep femoral collateral bed.

5. Aneurysmal swellings of the upper thigh whether due to simple fusiform dilatation to large false sacs connected with an arterial wound or to large false aneurysmal sacs in connection with arteriovenous fistulas must be approached with extreme caution since a tourniquet is rarely applicable above the lesion. When simple ligation proximal to the lesion is contemplated, one must be absolutely certain that an arteriovenous communication is not present. The latter is characterized by a continuous bruit and thrill, and usually by retardation in pulse rate and increase in blood pressure on closing the artery proximal to the lesion by digital pressure. If these signs are present proximal ligation must *not* be done and the lesion must be treated as an arteriovenous fistula.

When simple ligation of the artery in this region is indicated it should be done when

possible just distal to the branching of the deep femoral artery. Ligation and division is preferable to ligation in continuity particularly in the presence of arteriosclerosis, since danger of erosion at site of ligation is greatly reduced by division of the artery between ligatures.

A clinical experience in the case of a 77 year old man with a large fusiform aneurysm which had recently ruptured into the tissues transforming it into a pulsating hematoma is presented in which ligation and division of the superficial femoral artery with simultaneous ligation of the superficial femoral vein led to recovery and cure of the aneurysm.

6. When operating as an emergency upon a large pulsating swelling of the upper thigh due to an arterial injury or when operating upon a recently occurred arteriovenous fistula complicated by bleeding into the soft tissues and the production of false sacs or of a pulsating hematoma, or when operating upon any long standing arterial lesion in this region that might involve incision into a false sac the danger of severe and uncontrollable bleeding requires temporary occlusion of both the common iliac and external iliac arteries since occlusion of only one or the other would still provide sufficient collateral circulation to make the operation embarrassing by loss of blood or impossible through obscuring of the operative field by bleeding.

Such temporary occlusion is best accomplished through a separate incision through the tendinous structures just lateral to the lower third of the rectus muscle displacing the peritoneum upward, and exposing the common iliac artery at its origin. Tape ligatures including a small segment of rubber tubing will prevent injury to the vessel wall when tied and can easily be removed by cutting the tape over the tubing. The lesion is then approached through a longitudinal incision in the thigh directly over the common and superficial femoral arteries. Division of Pott's part ligament is a useful if possible.

The incision for the exposure of the common iliac artery will also permit removal of the lumbar sympathetic ganglia for the production of peripheral vasodilatation if this seems desirable (Gage and Ochsner).

7 In operations upon lesions of the neck involving the subclavian and axillary vessels, adequate exposure of the proximal artery in the first or second portions of the subclavian artery is obtained best by subperiosteal resection of the medial two-thirds of the clavicle with transverse incision and reflection of the periosteum in its midportion. Stabilization of the shoulder is not permanently impaired, and good function is possible in about 3 weeks. The added confidence provided by this procedure in being able to control both the proximal artery and vein is ample justification for such resection.

8 Two cases of arteriovenous fistula, one of the subclavian vessels and one of the transverse cervical vessels, are presented illustrating the value of such resection of the clavicle in exposing these vessels.

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TABLE L—INCIDENCE AND SURGICAL TREATMENT

Renal anomaly	Number of cases	Incidence ratio to total number of urologic cases	Dissectolobectomy	Pyelolithotomy	Nephrectomy	Transcystostomy	Removal of 1/2 of hypertrophied kidney	Ligation of ureter	Ligation of anomalous blood vessels	Nephroureterostomy	Partial nephrectomy	Excision of cysts	Pyeloplasty
Congenital solitary kidney		4											
Congenital hypoplastic kidney		10											
3. Congenital hydronephrosis	30	300											
Fused supernumerary kidney (34 cases)		43											
a. Bilateral with complete duplication of ureters		16											
b. Bilateral with incomplete duplication of ureters		1764											
c. Bilateral with right complete duplication of ureters and left incomplete duplication of ureter		304											
d. Unilateral with complete duplication of ureter	64	53											
e. Unilateral with incomplete duplication of ureter	64	53											
4. Free supernumerary kidney with ectopic vascular supply (vagina)		304											
5. Floating kidney	8	40											
6. Duplex kidney													
a. Unilateral duplex (crossed dysplasia)		364											
b. Unilateral duplex with ectopic ureteral orifice (internal)		1,304											
Exstrophic kidney (3 cases)		40											
a. Unilateral exstrophic (congenital pelvic kidney)		16											
b. Unilateral exstrophic (congenital pelvic kidney)		1,304											
Unilateral dysplasia (pelvic) with obstruction		1,304											
Polycystic kidney (bilateral)	8	40											
10. Solitary cysts		11											
Total	23	30	8	27				4					

*The figures are based on the series of 3,044 urological cases in 99,875 total hospital admissions at the Case Hospital, Baltimore, Maryland.

would be fatal and any conservative operation is fraught with great danger. Experience has also taught us that early diagnosis and prompt surgical treatment may mean the preservation of the integrity of the anomalous kidney whereas procrastination on the part of the patient or urologist in establishing the correct diagnosis may result in severe impairment in function or complete destruction of the parenchyma and necessitate radical surgery.

It is imperative that the urologist critically analyze all the information concerning the disease process in the anomalous kidney which has been obtained by the various diagnostic procedures. For example, pyelographic study may provide extremely valuable information

—the graphic demonstration of the alterations in the ascent of the kidney from the true pelvis constituting the varying degrees of ectopia; the abnormalities in rotation of the fused or ectopic kidney; the abnormal direction of the calyces and the anatomic variations and pathologic changes in the ureter. Such information may enable the surgeon to plan his operation with a minimum degree of discomfort or shock to the patient and with maximum prospects for relief or cure of the condition. The surgeon must bear in mind the recuperative powers of the individual for by virtue of this inherent power conservative operations for serious renal lesions often yield good results in children whereas the same con-

dition in adults demands radical surgery for relief or cure

Thorough preoperative care is of the utmost importance in determining the result of operative treatment of anomalous kidneys particularly in children. A thorough physical examination and laboratory studies may reveal constitutional defects: anemia, dehydration, acidosis, azotemia, myocardial damage, etc. These conditions must be quickly combatted or remedied by appropriate measures. The judicious use of blood transfusions and the liberal administration of proper fluids to overcome dehydration and acidosis and to stimulate renal excretion may mean the difference between success and failure in the operative treatment. Urinary infection may be controlled or combatted by employing sulfonamides or mandelic acid according to the specific bacteriologic indications.

The anesthetic of choice in operations on anomalous kidney depends upon the age of the patient. Ether appears to be the best anesthetic for children. Spinal anesthesia is preferable in adults as it facilitates good exposure by means of the complete relaxation of the tissues.

Operative plan. The successful surgical treatment of an anomalous kidney demands an orderly plan of operation as will be outlined. When the operative procedures are performed in a careful and precise manner, the end results are so uniformly satisfactory that the surgeon is more than amply rewarded for his painstaking efforts. Insufficient attention to any of the important steps in the operation may lead to unpleasant postoperative complications. However certain anatomic and pathological changes may exist: namely, abnormally fixed kidney, abnormal blood supply, unusual pathologic changes, and may interfere with the execution of one or more steps in the operation plan. The importance and value of this operative plan merit a very brief discussion of each of the following steps: (1) proper surgical approach, (2) careful attention to the vascular supply, (3) accurate hemostasis of parenchymal incisions, (4) disposition of the ureter, (5) adequate drainage of the kidney and renal fossa, (6) accurate closure of the operative wound.

TABLE II—INCIDENCE OF RENAL ANOMALIES IN 1100 CONSECUTIVE NECROPSIES, UNIVERSITY OF MARYLAND MEDICAL SCHOOL, DEPARTMENT OF PATHOLOGY

	Number of cases	Ratio
Congenital solitary kidney		1:550
Fused supernumerary kidney		
a. Bilateral with complete duplication of ureters	1	1:1100
b. Unilateral with complete duplication of ureters	0	1:125
c. Unilateral with incomplete duplication of ureter		1:550
Horseshoe kidney	5	1:220
Total	10	1:55

1. **Surgical approach.** As a rule, all operations on anomalous kidneys can be performed through the experimental lumbar route. This method permits good exposure and eliminates the danger of intra-abdominal infection resulting from contamination or spillage of infectious material. The type of incision varies with the position of the anomalous kidney. Although the fusion type of anomalous kidney is usually situated at the lower level than the normally developed kidney, it can be readily exposed by a lumbar incision of either the Israel or Young type. A lateral Mayo or Gibson incision may be employed in the case of a horseshoe kidney or sigmoid kidney situated at the level of, or slightly above, the sacral promontory, or in the case of a pelvic ectopic kidney. Two incisions, lumbar and lateral abdominal incisions, are required for a combined nephroureterectomy or heminephroureterectomy.

2. **Vascular supply.** Careful isolation and preparation of the vascular supply of the anomalous kidney are important steps in the operation. This procedure is often beset with great difficulties due to the anomalous origin, abnormal course, and variations in the number of vessels supplying the kidney. Each vessel must be carefully identified and individually ligated. In cases of fused supernumerary kidney and horseshoe kidney, temporary compression of the nutrient vessels to the segment to be removed enables the surgeon to determine the exact amount of renal tissue supplied by the vessels.

3. **Hemostasis.** The success of any operation on any anomalous kidney is often dependent upon accurate hemostasis. Faulty hemostasis of parenchymal incisions or cut surfaces

may result in subsequent oozing or delayed hemorrhage and require a secondary nephrectomy which may jeopardize the patient's life.

An unwarranted fear of extensive hemorrhage at the time of operation and of delayed hemorrhage following operation often exists in the mind of the surgeon who is contemplating excision of a portion of a kidney heminephrectomy removal of one-half of a horseshoe kidney symphysiotomy etc. The danger that a persistent urinary fistula may develop following operation is another hazard. These dangers can be eliminated or avoided by the judicious use of the proper type of renal incision and accurate hemostasis. All incisions into the renal parenchyma should be made through healthy renal tissue avoiding if possible opening of the pelvis or calyces. To excise a portion of a kidney or one segment of a fused kidney the use of wedge shaped incisions are of inestimable value. This type of incision provides adequate exposure of any opening in the calyces or pelvis to be sutured and permits thorough hemostasis by placing the sutures through the opposed parts of the wedge shaped incision.

To control bleeding from the cut surface of any renal incision the simple continuous through and-through suture of Telfer is more effective and less destructive of the renal parenchyma than are interrupted mattress sutures. The efficiency of these sutures may be increased by underpinning the sutures on both sides with small pieces of fat after the method of Beer and Hagenbach. The use of straight needles with catgut fused in their head (atraumatic sutures) produces a minimum amount of trauma especially when the needles are well greased with sterile vaseline. Hemostasis may also be obtained by the use of the flat ribbon gut as advocated by Lowley. Closure and hemostasis of renal incisions may be facilitated by the utilization of the capsule which has been preserved by being carefully stripped away from the site of the incision. The replacement and suturing of the previously stripped capsule over the approximated edges or raw surfaces not only serve to seal over the raw edges or surfaces and check oozing but also aid in the closure and healing of the wound by holding the hemostatic su-

tures in place. We have frequently placed a pad of fat from the subcutaneous or perirenal fat in the kidney incision for hemostatic purposes prior to the insertion of the hemostatic sutures in the parenchyma. For this purpose we prefer the use of fat instead of muscle. In an occasional case of heminephrectomy or symphysiotomy the operation may be attended with great difficulties due to incomplete exposure or anatomic disfigurements, and one may be forced to obtain hemostasis by applying curved hemostats which may be left in place from 3 to 5 days.

4. *Disposition of the ureter* The disposition of the ureter at the time of operation depends upon the pathologic process and the course of the ureter as well as the condition of the patient. As a rule the ureter of an anomalous kidney is handled in much the same manner as in treatment of a similar disease process in the normally developed kidney. Partial or complete ureterectomy may be indicated in cases of heminephrectomy of fused supernumerary kidney or removal of one half of a horseshoe kidney. Certain pathological processes in the ureter warrant a complete ureterectomy, i.e. tuberculosis, marked dilatation and tortuosity associated with stricture at the ureterovesical orifice or with an ectopic ureteral orifice. The surgeon must exercise great care in isolating the affected ureter in cases of fused supernumerary kidney with partial or complete ureteral duplication in order to avoid injury to the intrinsic blood supply and to integrity of the sound ureter which may be firmly adherent to the diseased or dilated ureter. Identification and isolation of the ureters at the time of operation may be simplified by passing ureteral catheters into the ureters prior to operation. Ordinarily the ureterectomy can be performed at the same time that the kidney is removed, but in some cases it may be necessary to remove the diseased ureter at a later date (two stage operation). When a combined nephroureterectomy is to be performed it is advisable first to isolate and ligate the ureter through a separate lateral abdominal incision and then to proceed with the nephrectomy through a second incision.

Careful study of the preoperative pyelograms of an anomalous kidney will often

reveal valuable information to the surgeon in regard to size, number, length, and course of the ureter, and the degree of rotation of the pelvis. Such information immediately warns the surgeon of the impracticability of nephropexy on the congenital pelvic kidney and suggests the degree of rotation essential to establish good drainage following heminephrectomy of fused supernumerary kidney or of the segments of the isthmus and follow nephropexy division of the kidney

5 *Drainage of the kidney and renal fossa*
Since anomalous kidneys are so frequently associated with concomitant abnormalities of the ureter and pelvis which may impede the drainage of the urine from the kidney or may even serve etiological factors responsible for the disease process in the anomalous kidney, it is imperative that good urinary drainage be established following any conservative operation. This can usually be accomplished by performing a nephropexy on the remaining portion of the kidney. The anomalous kidney should be anchored in a new position or replaced in such a manner as to insure good drainage through the existing channels. The author prefers the Dering method of nephropexy whenever anatomical and pathologic conditions permit. Otherwise, intrarenal or capsular sutures must be employed.

The advisability and practicability of intrarenal drainage in cases following heminephrectomy, partial resection of the kidney, and division of the isthmus of a horseshoe kidney are strongly questioned. It is the author's opinion that this procedure does not completely relieve tension on the suture line but, on the contrary, may interfere with primary healing, particularly when the drainage tube is inserted through a calyx previously unopened during the resection.

Following any operation on an anomalous kidney, drainage of the renal bed should be instituted to forestall the development of an infection about the operative site. The only exception is in cases of renal tuberculosis, in these patients such a procedure may lead to a persistent fistula. One or two Penrose (cigarette) drains usually suffice. However, some surgeons prefer to use a rubber tube 8 to 10 millimeters in diameter, but this method may

lead to perforation of the peritoneum or intestine as noted in one case in our clinic.

We have had unusually good results in the prevention of renal necrosis and postoperative infection of the renal fossa and of the incision due to escape of infected urine or pus during the operation by the liberal application of sulfanilamide powder (8 to 10 grams) over the renal bed and incision. This precautionary measure has undoubtedly reduced to a minimum the damage to the renal parenchyma by reparative sclerosis in the parenchyma and perirenal tissues incited by infection in the renal bed.

6 *Closure of the operative wound* The importance of this step is readily apparent and requires no further elaboration.

POSTOPERATIVE CARE

The success of any operation is in a large measure dependent upon thoroughness of the postoperative care, competent nursing and rigid medical supervision are absolutely essential. Careful attention must be paid to local and constitutional changes. Every effort must be made to forestall the development of dehydration, acidosis, azotemia, and anemia. Blood transfusions have proved of special supportive value particularly in children and chronically ill or debilitated adults. The urinary infection should be strongly combatted by oral therapy with appropriate urinary antiseptics. Experience has shown that a smooth postoperative course and a good end-result depend upon efficient nursing and medical care as well as on a carefully executed operation. The author is in accord with the view of Campbell that no patient be discharged as cured following an operation on an anomalous kidney complicated by urinary infection until at least two cultures of aseptically collected specimens of urine yield negative results.

The specific type of surgery and the results obtained in the patients treated by the author are indicated under each of the anomalies. There were 56 operations performed on anomalous kidneys for various reasons with no mortalities. We attribute our success to the careful preoperative study of each case, the judicious selection of cases for operation, a well planned operation, adequate preoperative

and postoperative medical care and good nursing

RENAL APLASIA AND HYPOPLASIA

It is important to differentiate between renal agenesis, aplasia, and hypoplasia. Agenesis infers a complete absence of kidney substance on the affected side and thus requires no surgical treatment. Aplasia indicates a faulty developed kidney which is much smaller than normal and is composed of embryonic or calcified glomeruli or tubules. The hypoplastic kidney is well developed from an anatomic and histologic standpoint but is diminutive or infantile in size. The aplastic kidney can be easily distinguished from a hypoplastic kidney by microscopic examination of the renal tissue. The differentiation can also be made before operation by functional (phthalein) tests. The hypoplastic kidney has a normal appearance time but excretes decidedly less than the normal amount per unit of time (1 to 3 per cent in $\frac{1}{2}$ hour). This decreased function is insufficient to sustain life if the entire secretory burden is thrust upon the hypoplastic kidney. The aplastic kidney is usually functionless.

Renal aplasia is a rare anomaly. Campbell reported 9 cases in 13,000 necropsies (1 in 1,444). Lisa and Levine observed only 1 in 1,200 consecutive necropsies. Renal hypoplasia is also a rare anomaly but occurs more frequently than aplasia. Geraghty and Plaggenmeyer found 3 cases in 3,940 necropsies. Harbitz encountered 22 cases in 7,778 necropsies (1/350). The author noted 13 cases of congenital hypoplasia in 3,684 urologic patients (1/283).

The surgical treatment of the aplastic or hypoplastic kidney should never be undertaken before a careful preoperative study including functional tests has been made. By ascertaining the condition of the kidney on the opposite side a surgical catastrophe can be prevented. The danger is readily apparent if vital functioning renal tissue is unwittingly incised or excised at operation in the presence of a hypoplastic or diseased kidney on the opposite side. By the same token any conservative or radical operation on a normally developed kidney may be extremely hazard-

ous in the presence of an aplastic or hypoplastic kidney on the opposite side. Eisen drath collected 17 cases in which death followed nephrectomy as a result of the failure of the opposite hypoplastic kidney to develop sufficient reserve power.

When the aplastic kidney is responsible for considerable discomfort or is the seat of a severe infection the only treatment is nephrectomy. Surgery of the hypoplastic kidney should be conservative unless the kidney is severely infected or functionally impaired. Nephrectomy was performed in 6 of our 13 cases; the pathological findings in these cases were severe pyelonephritis, 2 cases pyonephrosis, 3 cases and pyonephrosis with calculi 2 cases.

SUPERNUMERARY KIDNEY

Supernumerary kidney has been recognized for many years and has been referred to by a variety of descriptive terms, i.e. double kidney duplication or reduplication of the kidney free or fused supernumerary kidney fused kidneys, etc. The condition may be unilateral or bilateral. When two separate pelves are found to be free or fused on one side the upper pelvis is usually rudimentary and the parenchyma is hypoplastic, whereas the lower pelvis is well developed and the parenchyma possesses normal or near normal function. When the two pelves are intimately adherent or fused together the anomaly is known as a fused supernumerary kidney (Fig. 1). The surface of such kidneys may be smooth and uniform or show a definite groove or constriction at the junction of the two segments. When the upper rudimentary segment is distinctly separate and not connected in any way with the lower segment the anomaly is considered as a true or free supernumerary kidney. The blood supply to each segment is entirely separate in the majority of the cases.

The ureters in either anomaly may show a complete or incomplete duplication. When complete duplication is present the ureter of the upper pelvis is straighter and narrower than its mate. Each ureter may have its own sheath, but both ureters are usually enclosed partially or completely in a common sheath.

The two ureters may cross one or more times. The situation of their orifices may vary but ordinarily they are found on or at the side of the ureteral ridge. The orifice of the ureter to the lower pelvis is most frequently found to be superior and lateral whereas that of the upper pelvis is medial and inferior. The incomplete duplication may vary according to the regions in which they divide. The common site of bifurcation is in the upper third and least often in the lower third. Occasionally in cases of complete duplication of the ureter leading to the upper pelvis there may be an ectopic opening which may be difficult to diagnose. In the female this ectopic opening may be found in the urethra, vestibule, vagina, fallopian tube, or uterus and may cause urinary incontinence. In the male, the ectopic orifice may be located in the posterior urethra, the vas deferens, or the seminal vesicle causing no incontinence but leading to obstruction and to infection.

Fused supernumerary kidney is the most common renal anomaly. According to Campbell the incidence is 1 in 195 cases. Mertz recently analyzed a collected series of 316 cases of fused supernumerary kidneys and found the condition to be bilateral in 27 per cent. Harpster, Brown, and Delcher reviewed 382 renal anomalies and found 181 cases of unilateral fused supernumerary kidney with complete duplication of the ureters, 133 with incomplete unilateral duplication of the ureters and 40 bilateral fused supernumerary kidneys with complete duplication of the ureters. In the series of 3,684 urological patients there were 54 cases of supernumerary kidney (1.70). The relative incidence of various types of supernumerary kidney in this study is indicated in Table I. The most frequent types encountered are the unilateral fused supernumerary kidney with complete or incomplete duplication of the ureters. On the other hand, free supernumerary kidney is one of the rarest anomalies. In 1937, Geisinger collected 40 cases which included 1 patient (free supernumerary kidney with ectopic urethral orifice in the vagina) operated upon in our clinic and added 2 personal cases. Campbell found this anomaly only once in 26,450 necropsies.

Supernumerary kidneys are prone to develop the same pathologic conditions as the normal kidney. Conservative methods may be employed to treat some conditions, such as infections, ureteral stricture, ureteral stone, etc. Operative treatment presents a distinct surgical problem in each individual case. The following factors may exert a considerable influence upon the choice of operation, viz (a) function of each segment of the anomalous kidney, (b) function of the opposite kidney, (c) degree of infection in each segment, and (d) condition and position of the ureters and their orifices. The chief indications for operation are severe infections, calculi, tuberculosis, and neoplasm.

The following procedures have been employed with varying degrees of success, viz (1) ligation of the ureter to the affected segment, (2) transplantation of the ureter into the bladder or bowel, (3) lateral anastomosis of two ureters or implantation of one ureter into the other, (4) ureterolithotomy, pelvolithotomy or nephrolithotomy, (5) heminephrectomy, and (6) nephrectomy.

The simplest operation is ligation of the ureter to the affected segment. Following this operation the parenchyma on the affected side undergoes atrophy and ceases to function. This operation should be reserved for cases in which there is no active infection in the involved segment which may be responsible for subjective symptoms of renal origin, i.e., pain, hypertension, sympatheticotonia, etc.

Transplantation of the ureter into the bladder or bowel is an operation of necessity but never of choice. The operation is contraindicated except in unusual circumstances, as when the anomalous kidney is the only kidney and pathologic conditions exist in the bladder or lower ureter preventing conservative operative procedures. The same may be said of lateral anastomosis of both ureters and implantation of one ureter into the other.

Ureterolithotomy, pelvolithotomy and nephrolithotomy are indicated in cases of stone not associated with severe infection or marked stasis above the level of the stone. Conservative operations under the latter circumstances may mean subjecting the patient to an unwarranted surgical risk.

When the disease process—stone infection or tumor—has caused marked impairment of function or extensive destruction of the parenchyma, the operative procedure must be either heminephrectomy or nephrectomy as the situation demands. Campbell has performed 23 heminephrectomies for various pathologic lesions with only 1 death. He has admirably described the technique and indications for a one or two stage heminephroureterectomy. He has strongly emphasized the importance of the careful selection of cases in order that the remaining segment should not prove too small or become functionless and thus subject the patient to the hazards and risk of a secondary nephrectomy. Heminephrectomy is indicated when the involved segment is hopelessly destroyed and the remaining segment possesses good function, i.e. more than one half of the combined function of the anomalous kidney, and equivalent to at least one half the function of a normal kidney. The operation is feasible when there is sufficient tissue between the two segments to permit division, and the blood supply to the remaining segment can be preserved intact. Partial or complete ureterectomy must accompany the heminephrectomy. The length of ureter to be removed depends upon the nature of the pathologic process in ureter and condition of the patient (Fig. 2).

In 1937 the author had occasion to review the literature in regard to resection of the normal kidney (partial nephrectomy) and heminephrectomy of a double kidney. The total number of heminephrectomies reported up to date were 121 cases to which the author added 2 cases. In this series there were only 3 operative mortalities. The operation was performed for an ectopic ureter (10 cases) hydronephrosis (11 cases) hydronephrosis with renal calculi or ureteral calculi (7 cases) infected hydronephrosis (12 cases) pyonephrosis (11 cases) calculous pyonephrosis (11 cases) pyelonephritis (14 cases) tuberculosis (6 cases) neoplasms (2 cases) chronic nephritis (1 case) renal calculus with cortical abscesses (1 case), cystic disease (1 case) and undetermined (3 cases). A postoperative urinary fistula occurred in 6 cases. A secondary nephrectomy was required in 7 cases.

Nephrectomy is indicated when the disease process in one segment is of a neoplastic or tuberculous nature. It is also indicated when abnormalities in the shape of the kidney and its blood supply militate against a successful resection of one segment (Fig. 3).

In the 54 clinical cases reviewed by the author operative treatment was successfully employed in 17 cases. Nephrectomy was performed for pyonephrosis in 3 cases hydronephrosis complicated by ureteral stone or stricture 2 cases pyelonephritis, 2 cases tuberculosis, 1 case. Heminephrectomy was employed in 2 cases, namely (1) removal of upper half of right double kidney with complete duplication of ureters for chronic pyelonephritis and stone in the affected kidney segment and (2) removal of upper half of a left double kidney for pyonephrosis in a patient with bilateral fused supernumerary kidneys with bilateral complete duplication of the ureters. Ligation of the ureter leading to the upper rudimentary segment of a unilateral fused kidney with complete duplication of the ureters was carried out in 3 cases for nephralgic pain (sympatheticotonia) and in 1 case for chronic pyelonephritis associated with hypertension. Ureterolithotomy nephropexy and ligation of an anomalous blood vessel causing hydronephrosis were performed in single cases.

HORNSHOE KIDNEY

Hornshoe kidney is one of the common renal anomalies. Campbell found 60 cases in 16,480 necropsies (1:440) the condition was more frequently observed in children (1:335) than in adults (1:600). Motzfeld reported 92 cases in 73,489 necropsies (1:719). A hornshoe kidney was encountered in 8 cases in my series of 3,684 urological patients (1:460).

This anomalous kidney is subject to the same diseases as the normally developed kidney. The pathologic changes associated with urinary stasis are more frequently noted in this anomaly than in the normally developed kidney. This is due to interference with drainage from the pelvis and ureter which may be caused by abnormal rotation of the pelvis, lateral exit of the ureter from the pelvis, and compression of the ureter over the isthmus or by anomalous blood vessels (Fig. 4).



Fig 1 Bilateral pyelograms Bilateral fused supernumerary kidneys with bilateral complete duplication of the ureters A stone is present in the lower end of the right ureter leading to the upper rudimentary segment of the right kidney and was removed cystoscopically (SS, female, 52 years)

The indications for operative treatment of horseshoe kidney are essentially the same as they are for the normally developed kidney. Before any operation is undertaken on a horseshoe kidney, particularly removal of one-half, each case must be carefully studied from a pyelographic and functional standpoint. The importance of such study is borne out by an observation of Walters and Priestley who found an atrophic kidney incapable of sustaining life on one side of a horseshoe kidney. The most carefully planned operation on a horseshoe kidney may of necessity be altered by the anatomic and pathologic changes encountered at operation.

From a surgical standpoint, the patients with horseshoe kidney may be classified into two main groups, viz (1) those with pathologic lesions and symptoms of renal origin and (2) those with subjective symptoms of renal origin but with little or no pathologic changes—the so called “horseshoe kidney disease” of Gutierrez. The first group may be subjected

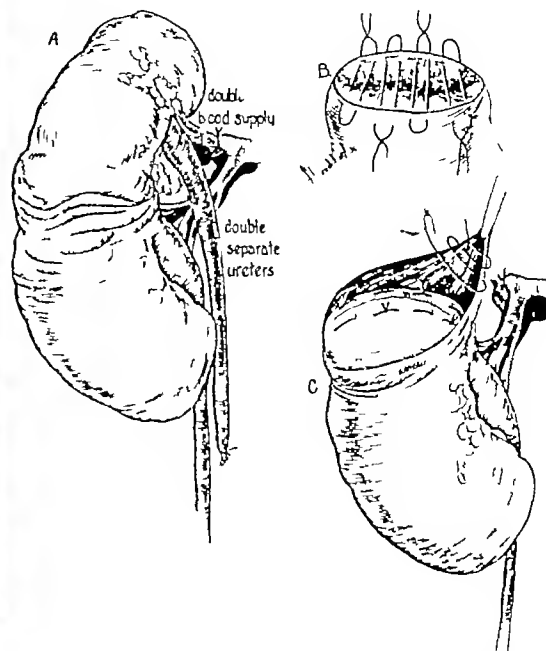


Fig 2 Sketch of operative technique in heminephrectomy (J L, female, 33 years. Calculus in upper half of right fused supernumerary kidney with complete duplication of ureters) A, Capsule retracted off the rudimentary kidney to be resected. B, Wedge shape excision of upper segment. C, Closure of capsule over the cut surface of the kidney.

to any operation performed on a normally developed kidney. In 1932 Walters and Priestley reported 50 cases in which patients were treated surgically which included nephrectomy, 16 cases, pelvolithotomy, 14 cases, nephrolithotomy, 2 cases, nephroureterectomy, 2 cases, division of an aberrant vessel, 1 case, excision of cyst, 1 case, and division of the isthmus, 1 case. The second group of patients is usually treated by division of the isthmus with restoration of one or both segments to their normal anatomic position by rotation and nephropexy.

When the disease process is confined to one half of the organ, any conservative operation can be performed as in the normal developed kidney. When the disease process has rendered one-half of the organ functionless or has destroyed the parenchyma, this half of the kidney may be removed provided the remain-

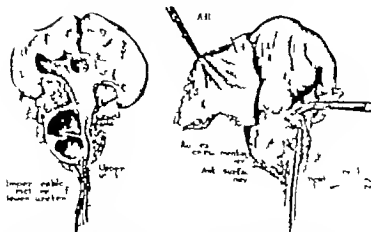


Fig. 3 Drawing of operative specimen. Right fused supernumerary kidney with complete duplication of ureters. Stone in upper third of ureter leading to lower renal segment removed 6 months prior to nephrectomy. Impermeable structure is site of ureterolithotomy incision. Primary hydromphrotic atrophy of lower segment and abscess in lower portion of the upper segment. (R. H., male 4 years)

ing half has adequate function. The latter operation has been termed a heminephrectomy but as the amount of tissue removed is equivalent to a normally developed kidney the

term resection or excision of one-half of a horseshoe kidney appears to be more accurate.

The accepted treatment for the cases of horseshoe kidney with symptoms of renal origin with little or no pathologic changes is division of the renal isthmus (symphysiotomy) followed by rotation and suspension of one or both halves of the organ. Prior to 1930 this operation has been performed on 12 occasions by various European surgeons. This operation has been popularized in this country by Donohue, Foley and Gutierrez. In 1940 Foley collected 10 cases from the literature and added 7 personal cases. During the operation care must be exercised to free the ureters, pelvis, and parenchyma from any fibrous bands or adhesions and to ligate any aberrant vessels which may interfere with rotation and suspension of the segment. The Deming method of nephropexy is preferred whenever possible since it is simple to execute and obviates the use of intrarenal sutures.

Hemostasis after division of the isthmus depends upon the nature of the tissue connecting the two halves. When the isthmus is composed of fibrous tissue simple ligation suffices. When the isthmus is composed of renal tissue hemostasis may be accomplished by utilizing either a through and-through



Fig. 4. Bilateral pyelograms 3 months after pyelolithotomy showing pyrocephrosis of left half of horseshoe kidney in same patient as in Figure 3. (A. L., male 7 years. Left half of horseshoe kidney removed)

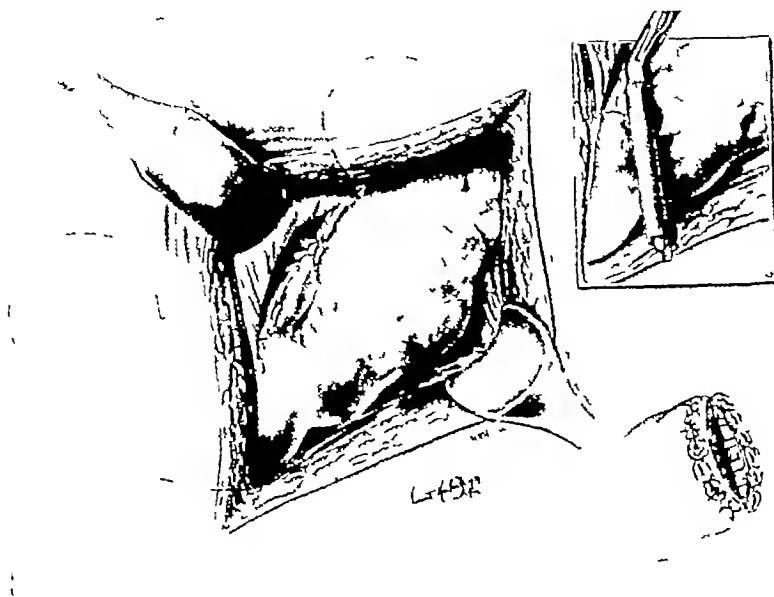


Fig 5 Drawing of operative technique in removing left half of horseshoe kidney (A L, male, 27 years) At the right, kidney is exposed through left lumbar incision At the upper left, rubber covered pedicle clamp is applied to isthmus prior to excising left half of horseshoe kidney by wedge shaped incisions At the lower left, hemostasis is obtained by use of continuous through and through Tuffier sutures with mattress sutures at each end Each suture is underpinned with fat after the method of Beer Hagenbach

Tuffier suture or interrupted mattress sutures of Beer-Hagenbach type In some cases, when the operation is beset with formidable anatomic difficulties, hemostasis must be obtained by applying curved hemostats for 3 to 5 days (Fig 5)

Operations on horseshoe kidneys should be performed extraperitoneally through a lumbar or lateral abdominal incision In the author's series of 8 cases, operative treatment was carried out in 5 cases Pyelolithotomy was employed in 3 cases Removal of one-half of the horseshoe kidney was performed in 2 cases calculous pyonephrosis and hypernephroma (Fig 6)

SIGMOID KIDNEY

Sigmoid kidney is one of the rarest types of renal anomalies Young distinguishes two types of sigmoid kidney (a) the true sigmoid kidney—each kidney on the correct side of the body but the fused portion is situated in the midline of the body, and (b) the unilateral elongated (or fused) kidney—both kidneys



Fig 6 Preoperative bilateral pyelograms in the case of a horseshoe kidney Defect in lower calyces of right half of horseshoe kidney caused by hypernephroma Arrow points to the outline of a tumor mass in right half of horseshoe kidney Incomplete filling of pelvis of left half (H S, male, 53 years)



Fig. 7. Pyelogram in the case of unilateral elongated kidney of sigmoid artery (I. A., male, 36 years). The calculus, situated in the upper calyx of the lower crossed dystopic kidney, as removed by pyelolithotomy.

fused on the same side of the body—a crossed dystopia. The incidence of sigmoid kidney in necropsy studies varies considerably. Morris cites 1 in 15,908 Stewart and Lodge 1 in 6,500, Thompson and Allen 2 in 10,373 and Campbell 3 in 12,080—a composite ratio of 1 in 6,409. In 1932 Pierson collected 118 cases from the literature and added a personal case.

Surgical treatment of this anomaly depends upon the nature of the pathologic process. The malformation *per se* requires no operation unless infection, stone formation, or tumor is superimposed or unless the anomaly produces subjective symptoms of renal origin. Pyelonephritis should be treated by chemotherapy first and supplemented by catheter drainage and lavage of the pelvis. If necessary, as in the case of a similar infection in the normally developed kidney.

Operative treatment usually consists of pyelotomy or nephrolithotomy for calculus ligation of anomalous vessels and ureterolithotomy. Division of the isthmus (symphy-



Fig. 8. Bilateral pyelograms showing left crossed pelvic kidney of crossed dystopic artery situated over right sacroiliac joint. Right kidney normal. Left kidney removed (or chronic pyelonephritis). (B. B. male 5 years.)

omy) is rarely performed due to the anatomic disfiguration associated with this anomaly. Foley recently reported a case of unilateral elongated kidney successfully treated by division of the isthmus and unilateral nephropexy. Removal of one-half of a sigmoid kidney is seldom performed due to the bizarre parenchymal and vascular abnormalities. Operation on a sigmoid kidney are usually performed through a lumbar or lateral abdominal incision which permits adequate extraperitoneal exposure.

A pyelolithotomy was successfully performed through a lateral (Libson incision in the above case (Fig. 7).

RENAL ECTOPIA

The ectopic kidney is a congenitally misplaced kidney which has failed to ascend to its normal position. It is usually found within the true pelvis or at the level of the sacral promontory. The blood supply of the ectopic kidney is derived from the adjacent large vessels. It is to be distinguished from the acquired

dystopic kidney (nephroptosis) whose variable mobility may be due to intrinsic or extrinsic factors. The congenital ectopic kidney is usually unilaterally displaced on the side that it normally belongs but occasionally may be of the crossed dystopic variety as noted in one of the author's cases (fig. 8). The latter type has been estimated by Beer and Hyman as 1 in 8,000 cases. Bilateral renal ectopia is extremely rare and occurs once in 22,400 cases according to Stevens.

Clark observed that a pelvic ectopic kidney of either the unilateral or bilateral variety occurred in 13 of 4,215 consecutive necropsies. In 1911 Dorland collected 121 clinical cases of ectopic kidney. Guzzetti and Pariset found 18 cases in 20,000 necropsies. Thomas and Barton reported the incidence of congenital ectopic kidney as 1 in 522 necropsies. Campbell's figures are in accord with the latter's finding namely 15 cases in 17,050 necropsies (1/800).

The author encountered 5 cases of congenital ectopic kidney in 1,654 urological patients (1/465). Seven of these patients had a congenital pelvic kidney, 6 were of simple dystopic variety, and 1, a crossed dystopia.

It is generally recognized that slight degrees of congenital displacements are not unusual but marked degrees of displacements are relatively rare. Congenital pelvic kidneys are frequently associated with other congenital malformations especially in the genital tract in the female. The ectopic kidney may be structurally and functionally normal and consequently never gives rise to symptoms. However, since the congenital ectopic kidney and ureter are malformed, they are susceptible to the same disease processes as the normally situated kidney. Straker reported 12 cases of hydronephrosis in 6 pyonephroses in a series of 27 cases. Pyelonephritis, calculi, tuberculous, hypernephroma, and sarcoma have also been reported. Pain and hematuria have been two of the most outstanding symptoms in the author's series. A pelvic ectopic kidney in the female may suffer serious impairment of function by the increased pelvic pressure of the enlarging uterus. On the other hand the pelvic ectopic kidney may interfere with normal delivery and necessitate cesarean sec-

tion. Cases have been reported in which a pelvic ectopic kidney has been erroneously diagnosed as a uterine fibroid tumor or an ovarian tumor the true nature of which was revealed at exploratory operation. Not infrequently the appendix, tubes or ovaries have been removed for pain produced by the ectopic kidney.

The treatment of the various pathologic conditions in the ectopic kidney is essentially the same as in the normally situated kidney. Pyelonephritis and small calculi in the pelvis and ureter may be treated by the same conservative methods outlined for the other anomalies. Operations to replace the ectopic kidney in a more favorable position have been attempted but are always unsuccessful due to the abnormally short ureter, firm fixation of the kidney, and its abnormal vascular supply derived from the regional vascular trunks. If the disease process in the ectopic kidney has produced a serious impairment in function or marked destruction of the parenchyma or is accompanied by severe hematuria or considerable pain which cannot be corrected by palliative measures, nephrectomy is obviously indicated provided there is a healthy kidney on the opposite side.

When the ectopic kidney is situated in the true pelvis operative treatment can be performed either by the transperitoneal route through a suprapubic midline incision or, preferably, by the extraperitoneal approach through a lateral Gibson incision. When the kidney is situated at the level of or slightly above, the sacral promontory, the operation can be carried out extraperitoneally through a lateral Gibson or Mayo incision.

Nephrectomy was successfully performed in 4 cases through a lateral Gibson incision. Three cases were of the simple dystopic variety and 1, a crossed dystopia. The kidney was removed because of severe persistent hematuria (1 case), recurrent pain associated with hydronephrosis (1 case), pyelonephritis (1 case), and pyelonephritis, pyonephrosis, and renal calculus (1 case).

SUMMARY AND CONCLUSIONS

It is readily apparent that any clinical deductions, which are based on the analysis of a

relatively small series of renal anomalies treated surgically must necessarily be guarded. However when this knowledge is supplemented and substantiated by the observations and results of competent surgeons in this country and abroad as noted in a review of the literature the evidence appears to be sufficient to warrant the following conclusions:

1. Congenital anomalies of the kidney are susceptible to the same pathologic complications as is the normally developed kidney.

2. Complete urological examination, i.e., cystoscopic ureteral catheterization, retrograde pyelography, intravenous urography, and renal functional tests, is of inestimable value in the diagnosis and treatment of renal anomalies.

3. The possibility of a renal anomaly must be borne in mind by the urologist and surgeon in patients with an obscure abdominal, pelvic or retroperitoneal mass and in patients with ill defined symptoms of renal origin.

4. The treatment of pathologic complications in the anomalous kidney depends not only upon the type of anomaly but also upon the character of the symptoms and the extent of the renal damage and functional impairment.

5. Asymptomatic patients who present no renal pathology require no treatment. Such patients should be informed of the condition and advised to return for re-examination at frequent intervals.

6. The successful surgical treatment of an anomalous kidney demands an orderly plan of operation viz (1) proper surgical approach i.e. extraperitoneal operation through a lumbar or lateral abdominal incision (2) careful attention to the vascular supply (3) accurate hemostasis of parenchymal incisions (4) proper disposition of the ureter (5) adequate drainage of the kidney and renal fossa and (6) accurate closure of the operative wound.

The success or failure of the operative treatment of anomalous kidneys particularly in children is considerably influenced by the proper medical treatment of constitutional defects and by good nursing in the preoperative and postoperative period.

The operative results which were obtained in the 56 cases of renal anomalies were uni-

formly good. There were no deaths in this series of cases.

By adhering to the principles indicated herein and by adopting the precautions mentioned many unnecessary abdominal and renal exploratory operations will be avoided. For the same reasons many anomalous kidneys which hitherto have been needlessly and unwittingly sacrificed will be saved.

A simple classification of renal anomalies modified after Young is presented in order to clarify the types of renal anomalies from a structural standpoint and to avoid the confusion arising from the use of various non-descriptive terms.

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CARCINOMA OF THE RECTUM

Conclusions Based on 12 Years Experience with Combined Abdominoperineal Resection

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In 1931 in the surgical clinic of the University Hospital an intensive study of some of the problems relating to carcinoma of the rectum and rectosigmoid was begun in an attempt among other things to evaluate the various forms of treatment and to standardize the operative procedures insofar as possible. The principles, enunciated by Miles (12) as the result of his painstaking researches into the modes of spread of this disease seemed to make abdominoperineal resection the only logical procedure if an appreciable number of cures was to be expected. Our early experiences with this radical type of resection soon convinced us that in our hands a one stage operation was preferable to any carried out in multiple sessions many opinions to the contrary notwithstanding. From the technical standpoint the single stage procedure proved to be considerably easier than the second half of the two stage operation and when the patient had been properly prepared and rehabilitated we concluded that it could be carried out with a mortality no higher than that associated with equally radical multi-stage methods, except perhaps in the unusual case. In 1936 we (5) published the results of our observations in this matter the study comprising a period of 5 years during which time we had had the opportunity of studying 270 patients with rectal cancer. The operability in this first series of cases was 49 per cent whereas the operative mortality for the one stage combined abdominoperineal resection was 16.5 per cent. Since this original report was made as experience has increased we find that our views as to the major and fundamental problems involved have changed but little and we are now more than ever convinced that

in our hands the single stage operation is the one of choice with but few exceptions.

The present report is concerned with the group of patients with cancer of the rectum and rectosigmoid observed during the 6¹/₂ year period from January 1, 1936 to July 1, 1942. During this time 571 patients were seen in consultation. Instances of rare rectal neoplasms, e.g. leiomyosarcoma, lymphoblastoma and melanoblastoma, as well as of rectal endometriosis are not included in the study. In the group there were 352 males (61.6%) and 219 females (38.4%). The oldest patient was 82 and the youngest 22 the average age for the series being 56.2 years. The diagnosis in all cases was made by means of the usual examinations i.e. digital palpation, sigmoidoscopy with barium contrast enema studies when indicated. Histologic confirmation of the diagnoses was obtained by means of biopsy. With regard to the latter procedure we are in agreement with the statement of Ilavden and Shedden that in rectal or rectosigmoid carcinoma biopsy is always advisable and never harmful. We have not been aware of harm coming from a carefully taken biopsy. Accidents or deleterious effects resulting from the procedure are usually due to errors in technique in unskilled hands. The advantages of a microscopically verified diagnosis are obvious and not infrequently the information obtained by biopsy is revelatory as in the case of certain inflammatory lesions, lymphoblastoma, endometriosis etc. when a patient may thereby be spared a mutilating operation. In the case of large adenomatous polyps one or even several negative biopsy studies should not be accepted as final proof of benignity. On several such occasions adenocarcinoma was discovered only after the entire polyp had been removed and the whole specimen exam-

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med by the pathologist. Since adenomatous polyps are potentially malignant, complete removal is demanded once the diagnosis is made, and if this practice were universally carried out, many rectal cancers would be prevented since the evidence available at the present time indicates that the great majority of rectal carcinomas develop upon the basis of pre-existing polyps.

As in our earlier series, a certain number of patients were referred for diagnosis only, refused any form of treatment, or went elsewhere for care. Sixty-three patients fell into this category and will not be considered further. There remained 568 patients for whom treatment was recommended and carried out or who, after careful appraisal from all standpoints, were judged to be beyond the reach of curative or palliative therapy and who were therefore given only supportive or symptomatic treatment.

PALLIATIVE OPERATIONS AND CONSERVATIVE THERAPY

Of the aforementioned 568 patients who entered the hospital for detailed investigation and treatment, 286 were regarded as unsuitable subjects for radical operative procedures (Table I). In most instances inoperability was accounted for by far advanced lesions with metastases, and for these patients only palliative measures could be offered. Thirty-seven patients, or 7.5 per cent of those entering the hospital for study, were regarded as hopelessly inoperable and in the absence of obstruction received no definitive treatment. Three of these patients had already had colostomies performed prior to entry. Among the more common contraindications to operation relating to the neoplasm were pulmonary, skeletal or extensive hepatic metastases, ascites, recto-vaginal and ileosigmoidal fistula, or a large mass firmly fixed in and filling the pelvis. The general contraindications to operation most commonly encountered were in addition to the ordinary ones, i. e., cardio-renal vascular disease, pulmonary tuberculosis or pulmonary suppuration and obesity; such disorders as insanity, low renal function due to absence or non-function (previous nephrectomy) and associated severe chronic ulcerative colitis. In ad-

TABLE I.—RADICAL OPERATION NOT PERFORMED

	Cases
Not treated	63
Inoperable—no treatment advised	37
Exploratory laparotomy	7
Cauterization, radium or x ray (in conjunction with colostomy)—8	5
Local excision polyp	3
Cecostomy	7
Colostomy	144
Total	286

dition several instances of multiple malignant neoplasms were encountered, e. g., associated advanced carcinoma of the cervix, uteri, ovary, breast, cecum, and transverse colon. Moreover, in 2 patients the presence of a cutaneous melanoblastoma with metastases served as a contraindication to operative treatment of the rectal cancer. Peritoneoscopy was employed in many of these cases and often proved to be of valuable assistance in the final decision regarding management of the case by disclosing extensive hepatic metastases or peritoneal implants, addenda indicating that palliative surgery would be scarcely worth while. That the 37 patients in the inoperable group were in a hopeless state is attested to by the fact that 12, or 35.1 per cent of them, died in hospital.

Seven patients with doubtfully operable lesions were subjected to exploratory laparotomy. Five of these patients had already had simple loop colostomies performed elsewhere at an earlier date. One patient died of bronchopneumonia (necropsy) following exploration only, making an operative mortality of 14.3 per cent for this small group.

At the time of hospital admission 7 patients exhibited high grade intestinal obstruction and cecostomy was necessary as an emergency life-saving measure. All of these patients had hopelessly inoperable neoplasms and cecostomy for decompression was the only procedure justified and it constituted a desperate attempt at relief of the obstruction. Five of these patients died following cecostomy, thus making a hospital mortality of 71.4 per cent.

Twenty-five patients were treated by surgical diathermy, cauterization, x ray, radium, or combinations of these agents. There was 1 hospital death associated with this form of treatment, 4 weeks after treatment had been completed. Of course, a radical operation was

TABLE II.—COLOSTOMY ONLY PERFORMED

	Cases
Colostomy as first stage (Death before second or second stage abandoned because of poor condition)	4
Palliative colostomy	
Old age	
Bad mal	4
Local lesion operable but hepatic metastases	4
Local lesion operable—in or free	55
Locally inoperable—lik hepatic metastases	30
Abdominal carcinomatous	
General peritoneal due to perforation	
Total	44
Mortality— 7.4 per cent	

ropry) While it is generally agreed that this type of therapy is inferior to surgery. It probably has a limited place in our armamentarium. Although it is difficult to formulate the indications for this conservative type of treatment we have employed it under certain circumstances, as illustrated by the following examples.

1. Intensive deep x ray therapy was used in tumors of undifferentiated cell type in certain of the younger patients who were in reasonably good physical condition and whose lesions were not resectable because of massive invasion of the perirectal structures but in whom distant metastases could not be demonstrated. In general the results in these cases were disappointing and the questionable short extension of life compared with the time expense and discomfort attendant upon treatment seemed to make it of questionable value. The end results were essentially the same with and without a complementary colostomy. The only advantage of the colostomy is in the presence of obstruction and the fact that the findings at laparotomy are often necessary to determine the exact status of the disease.

2. In a few patients with favorable lesions who refused any type of operative procedure these agents were employed usually against better judgement since treatment of this type can hardly be considered as curative.

3. A small group of patients with serious physical defects, or who because of age or obesity were unfit for surgical procedures was advised to have this form of treatment. To our knowledge the best results achieved from the use of these physical agents were in those patients with rather favorable or small operable lesion. In several cases under radium

therapy the lesion was observed to diminish in size and subsequently when microscopic examination of the tissue was carried out by the pathologist (death sometime later from other cause—necropsy) the presence of living cancer cells was debatable. In spite of the initial subsidence in the activity of the neoplasm the clinical improvement is most often of brief duration and any favorable response will usually be but temporary. In general all of these methods are purely palliative and they should be employed only when the appropriate surgical therapy is clearly contraindicated.

In three instances biopsy material taken from what seemed clinically to be a benign adenomatous polyp revealed the existence of a very early adenocarcinoma. Each of these patients was treated by complete excision of the polyp with thorough cauterization of the base. While such treatment may involve a somewhat greater danger of recurrence the method has seemed permissible in these exceptionally early lesions in order temporarily at least to avoid a colostomy. Obviously patients so treated should report frequently for check-up examinations in order to determine promptly the presence of any recurrence. In 1 case abdominoperineal resection was necessitated 4 years later because of recurrence following the local excision of the cancerous polyp. Another patient following such local removal later developed early carcinoma in a second adenomatous polyp but without recurrence at the site of the original lesion. The same form of treatment was again employed.

In 144 cases simple loop colostomy only was performed (Table II). In 140 it was a palliative operation performed for nonresectable lesions whereas in the 4 remaining cases it constituted the first stage of a proposed two stage resection (method of Lockhart Mummery). Three of these 4 patients died following the colostomy before the second stage could be undertaken while in the remaining case the condition following colostomy was such that plan for a second stage were abandoned. The incidence of palliative colostomy among patients hospitalized was 27.8 per cent. The mortality for simple colostomy remains disturbingly high as evinced by the fact that there were 25 operative death in 144 opera-

TABLE III — OPERATIVE DEATHS FOLLOWING
COLOSTOMY

Cause of death	With necropsy No of cases	Without necropsy No of cases
1 Peritonitis—pelvic abscess etc	4	1
2 Pulmonary sepsis—pneumonia etc lectasis etc	3	—
3 Cancer cachexia	1	—
4 Cardiovascular accidents	—	5
5 Pulmonary embolism	3	1
6 Peritonitis and pulmonary embolism	2	—
7 Perforation of cecum (2d primary carcinoma)	1	—
8 Intestinal obstruction	1	—
9 Pulmonary tuberculosis	1	—
Total	16	9

144 cases, 25 deaths, mortality, 17.4 per cent

tions, a mortality of 17.4 per cent. This figure is slightly lower than in the series previously reported as, at that time, the mortality for colostomy was 22 per cent. The causes of death are given in Table III. As will be noted, infection in the peritoneal cavity or the late sequelae of such infections accounted for most of the deaths whereas cardiovascular accidents including pulmonary embolism were second in importance. In the absence of obstruction it is doubtful whether colostomy adds greatly to a patient's comfort. When severe tenesmus or bleeding is present diversion of the fecal stream may be worth while but whether it should be advocated as a routine procedure in frankly inoperable cases is extremely doubtful. Babcock is of this same opinion and reports a mortality of 30 per cent for simple colostomy in cases of far advanced rectal cancer.

Since in many instances the final decision regarding resectability must be made at the time of laparotomy it has been our practice to prepare carefully every patient of this type as for the complete operation. If at the time of exploration an inoperable situation is encountered, colostomy is usually performed utilizing the same lower left rectus incision for the exteriorization of the sigmoid loop in order to avoid the necessity of a possible second laparotomy for the relief of obstruction at a later date. Stone has suggested precolostomy in these cases, the bowel being implanted in the wound to be opened by puncture later if and when it becomes necessary. With this expedient we have had no experience. In general

TABLE IV — RADICAL OPERATIONS

Sex incidence		No. of cases	Per cent
Males		164	57.5
Females		121	42.5
Total		285	100.0
Age incidence		No. of cases	Per cent
—		—	—
Age		—	—
19-30 incl		8	2.8
31-40 incl		26	9.1
41-50 incl		63	22.1
51-60 incl		96	33.7
61-70 incl		82	28.8
71-80 incl		10	3.5
Total		285	100.0
Oldest patient		78	
Youngest patient		22	
Average age		54.5 years	

TABLE V — RADICAL OPERATIONS

One stage combined abdominoperineal resection	269
Two stage combined abdominoperineal resection	5
Colostomy and perineal excision	9
High colostomy with perineal excision and anastomosis	2
Total	285

Resections performed in 56.1 per cent of cases

with the known short life expectancy and the high mortality of colostomy in the terminal stages of rectal cancer, and the questionable benefits afforded by the operation, the trend in our clinic has been to employ it much less frequently than formerly. After observing the subsequent course of many of these patients, one agrees with the philosophy of the late Daniel Fiske Jones (9) who urged removal of the tumor whenever possible since "the condition of patients after removal of the growth and a colostomy cannot be compared with the physical discomforts, displeasures, and mental effect which follows a simple colostomy."

Radical resections were performed in 285 cases, or 56.1 per cent of the cases (Table V). Extirpation of the lesion was accomplished by means of combined abdominoperineal resection in 274 cases, or 96 per cent of the resections. Colostomy with posterior excision was employed nine times and high colostomy followed by perineal excision and primary suture anastomosis twice. While abdominoperineal resection is admittedly the procedure of choice for tumors situated at, or distal to, the rectosigmoid junction, nevertheless, in any

large series of cases, a certain few instances will be encountered in which the risk of such a procedure is unjustifiable and for these patients in poor general condition due to age obesity or other causes some compromise must be accepted. The 9 patients treated by the Mumery type of operation were of this type and had low lying lesions and for them the more radical procedures were considered too hazardous. It will be noted that this procedure was employed in only 3.2 per cent of the resected cases as compared with its use in 6.6 per cent in the series of cases previously reported. That the Mumery type of operation is not a proper one for general use goes without saying. In addition to being unsufficiently radical in so far as removal of the lymph nodes involved in the zone of upward spread is concerned the colostomy associated with this operation has most of the disagreeable features of the simple loop or double barrelled colostomy employed as a palliative procedure. It is difficult to care for because of its size and there continues to be a profuse discharge of mucus from the distal end of the divided bowel, and only too frequently a mucus perineal fistula ensues. Because of these troublesome features in a small group of our own patients who had done well for sometime following this type of operation, we were prompted to remove this lower blind segment of bowel at a later date. Such an operative procedure was also performed upon 4 patients who had had the Mumery type of operation elsewhere and interestingly enough in 2 positive lymph nodes were discovered upon microscopic examination of the specimen removed. In the group of 9 patients treated by colostomy and perineal excision there were 2 operative deaths. One was due to postoperative hemorrhage from the posterior wound in an elderly man who promptly succumbed following a moderate blood loss. The other patient died from a residual subdiaphragmatic abscess consequent upon peritonitis after a prolonged hospital sojourn. The 2 patients treated by high temporary colostomy and perineal excision and anastomosis were so treated at their urgent insistence to avoid a permanent colostomy. The fact that both developed recurrences within a year has dampened our enthusiasm for the procedure.

Five patients were treated by the two stage combined abdominoperineal resection. The technique employed was essentially that devised by Lahey and described in detail by Cattell. There were 2 deaths, 1 accounted for by a severe wound infection and 1 from pneumonia. This operation was elected under the following circumstances: (1) when in spite of adequate preparation, at the time of operation there was still a considerable degree of large bowel obstruction (2) when during the course of a proposed one stage operation, perforation accidentally occurred in the lower segment following transection of the sigmoid (3) in the presence of a pelvic abscess due to a subacute perforation of the lesion drainage being instituted at the first stage (4) when laparotomy was performed for the removal of uterine fibroids and an unsuspected carcinoma of the rectosigmoid was encountered, the meticulous preparation of the bowel ordinarily employed prior to radical operations on the colon and rectum having been omitted.

The remaining 269 resections were performed by the Miles technique the essential features of the operation being the same for all cases.

DETAILS OF OPERATION

1 Preliminary preparation. Patients remained in the hospital on an average of 5 to 7 days prior to surgery. During this time the necessary supplemental examinations regarding cardiac status renal function etc., etc. were made. Nutritional disorders were corrected by the appropriate therapy vitamin supplement being given routinely. Blood transfusions were used liberally in order to insure a hemoglobin reading of at least 70 per cent. A low residue high carbohydrate diet was prescribed and patients were urged to ingest additional carbohydrates e.g. candy sweetened fruit juices etc. between feedings. Catharus was instituted by the administration of magnesium sulfate. The daily dose was 1 ounce of the drug the crystals being dissolved in 8 ounces of water and 1 ounce of this preparation was administered each hour for 8 doses. If this proved too vigorous the magnesium sulfate preparation was given in half strength this regimen being continued up to the day prior to operation. On this day the catharsis was discon-

m. L. Cummings



Fig. 1. Permanent type of loop colostomy used in inoperable cases. The sigmoid loop has been exteriorized through the original main incision. A small opening has been made in the mesentery of the sigmoid and a type inserted thus drawing the sigmoid well forward in the wound. The peritoneum and fascia have been closed above and below the exteriorized loop. Two V or wedge incisions have been made in the lateral skin edge. The upper and lower limbs of the sigmoid loop fit into these notches when the skin is closed.

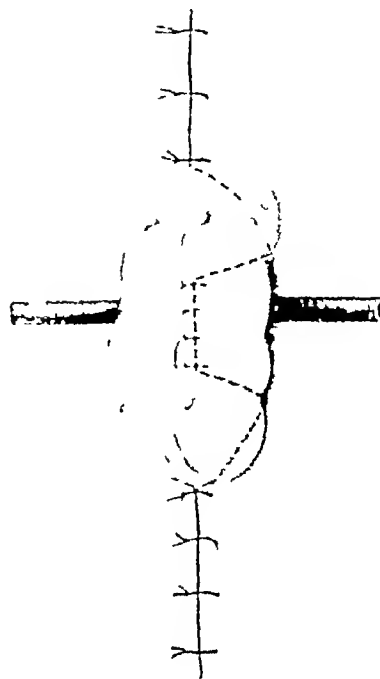


Fig. 2. The skin incision has been closed. The central tongue of skin created by the two V incisions in the lateral skin edge, has been drawn through the opening in the mesentery of the sigmoid and sutured to the opposite side. A stiff rubber tube is also drawn through the opening in the mesentery above the skin bridge, in order to maintain the sigmoid loop in position. When the colostomy is opened several days later, the sigmoid is transected completely. The final result is a permanent bridge of skin which separates the proximal and distal ends of the bowel.

tinued and paregoric given in several 1 drachm doses, with a sedative (barbiturate) at night in order to insure rest. This plan of medical decompression was successful in relieving mild degrees of obstruction in all but a few instances. In 5 cases persistent obstruction necessitated preliminary cecostomy. Surgical decompression by this means should be resorted to without delay when it becomes evident that conservative measures are ineffectual. Following cecostomy the definitive operation may usually be performed in 7 to 10 days. After a considerable experience with peritoneal vaccination by means of colibac-tragen (Steinberg) it has been discontinued.

It now seems to be unnecessary as postoperative peritonitis is rarely a serious complication and when it does occur it is usually the result of gross soiling of the peritoneum, and more effective methods of meeting such an accident are now available. While no serious or harmful effects were observed from the use of the vaccine in several hundred cases, its use results in considerable discomfort. For the most part chemotherapy was not used during the period of preparation. Early in the series a small group of patients was treated with sulfanilamide administered orally or intravenously for 48 hours prior to operation in order to establish a blood level of 8 to 10 milligrams



Fig. 3. The abdominal portion of the operation has been completed. Not the excess amount of the dried proximal jejunum exteriorized for the colostomy and the small stab incision in the flank through which it is drawn. The catheter for decompression of the bowel is inserted 1 inch or 2 days or 3 inches depending upon the case.



Fig. 4. Following the removal of the continuous retroperitoneal adhesions, the colostomy has been trimmed to a length of 3 centimeters. The removal of the excess bowel is performed by means of knife excision rather than with the cautery, and subsequently all bleeding points are carefully ligated.

per cent. If this drug is to be used we now believe that it is best administered intraperitoneally at the time of operation (Coller and Jackson 8). Sulfaguanidine was tried for a time and discarded. At present succinyl sulfathiazole is being given a trial. In order to increase resectability every patient not clearly inoperable was prepared as for the radical operation and the final decision as to the feasibility and wisdom of attempting removal reserved until the time of the celiotomy.

2. Anesthesia. Almost without exception a long acting spinal anesthetic (nupercaine 1:1500 aqueous solution) was employed in doses of 15 to 17 cubic centimeters and provided ideal operating conditions. Continuous spinal as recommended by Lemmon has not been used. The nupercaine spinal usually gives complete anesthesia for the duration of the operation, or in long difficult cases at least throughout the abdominal part of the procedure whereupon supplemental anesthesia by

means of inhalation anesthesia (cyclopropane or nitrous oxide-oxygen-ether) is entirely adequate for completion of perineal excision.

Shortly before the operation is begun an indwelling Foley catheter is inserted and is allowed to drain during the operation. This serves to keep the bladder empty during the procedure. An intravenous infusion of 5 per cent dextrose solution is started in an arm vein as the operation begins. If necessary blood or plasma may be quickly substituted.

3. Operation. Exploration is first carried out through a low right rectus incision merely large enough to admit the examining hand. The use of a sterile lubricant facilitates the exploration. If the complete operation is to be performed the incision is then enlarged considerably. If the case is judged to be inoperable and palliative colostomy is thought indicated, a permanent type of loop colostomy is made this same incision being utilized. For such a colostomy the technique shown in Fig.

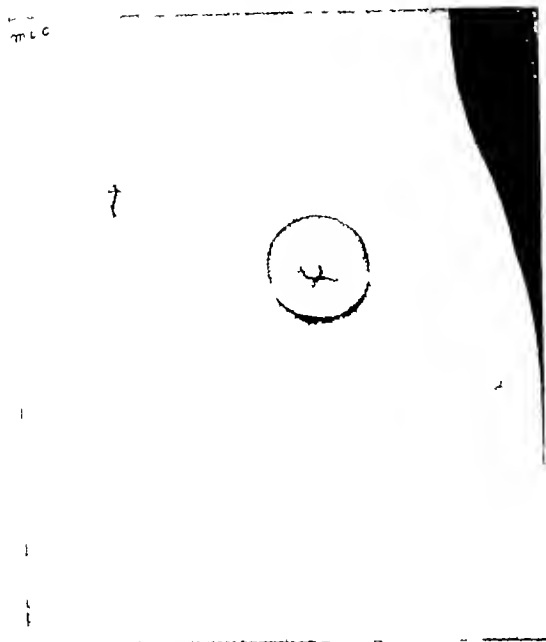


Fig 5 The end colostomy as it appears several months later. The mucosa has become everted and the colostomy protrudes a short distance beyond the level of the skin.

ures 1 and 2 has proved very satisfactory. As previously mentioned, simple colostomy is performed far less frequently than formerly, whereas more and more palliative resections are performed. With greater familiarity with the operation, improvements in preoperative and postoperative care and in anesthesia and with the institution of a blood and plasma bank, this has become practicable without an excessive mortality. Rectal cancer is now dealt with in a manner similar to that employed for many years in dealing with cancer of the stomach. In the latter lesion, palliative short-circuit operations have proved well-nigh worthless, whereas if resection of the lesion is performed, even though neoplasm in lymph nodes, liver, or pancreas may of necessity be left behind, the end-results have demonstrated beyond a doubt, the worth of the procedure. Similarly in carcinoma of the rectum, a few hepatic metastases need not contraindicate resection and even though complete eradication of the disease locally is impossible, resection is the procedure of choice. Moreover, extension of the neoplasm into adjacent struc-

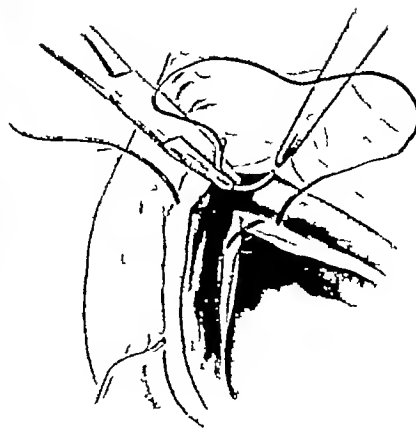


Fig 6 The main incision is being closed with a series of interrupted figure-of-eight sutures of No. 30, stainless steel wire. Both peritoneum and anterior rectus sheath are included in these sutures.

tures, e.g., uterus, ovaries, small intestine, vagina, or even ureter or bladder often may be dealt with by excision of the diseased tissues. The feasibility of extensive resections of the bladder in such cases has been discussed recently by Bowers. Six patients with cancer of the rectum and hereditary multiple polyposis of the colon and one of rectal carcinoma superimposed upon chronic ulcerative colitis required ultimate total colectomy, the rectal lesion being first dealt with by combined abdominoperineal resection. Since many of the patients are elderly men not infrequently large inguinal hernias are present. The presence of a hernia especially on the left adds immeasurably to the difficulties in the subsequent management of the colostomy. Hence such hernias are always repaired from within the abdomen at the time of the operation. This plan has been eminently successful and to date no recurrences of the hernia have been observed. The main steps of the resection of the rectum are carried out as originally suggested by Miles (13). Following a trial with several methods of establishing the end colostomy, the most satisfactory one has been with the use of a small stab wound to the left of the main incision and well above the anterior iliac spine (Figs. 3, 4, and 5). This incision is made barely

hand wound infection occurs all too frequently and often with fatal outcome. Correction of nutritional disturbances prior to operation, the free use of blood or plasma transfusions, an aseptic technique in dealing with the divided bowel ends, the use of nonabsorbable suture material, and scrupulous care in the closure of the wound will minimize this source of difficulty. The use of the sulfonamide drugs in the wound has not proved of value. Since the subcutaneous fat tolerates these drugs badly, the use of them locally results in indurated wounds and delayed healing. If gross soiling or contamination of the field occurs during operation, delayed primary closure of the skin as described by Collier and Valk (6) is indicated. Similarly in second stage operations when a colostomy is present, this method of closure should be employed. In 5 instances disruption of the abdominal wound or evisceration necessitated secondary closure by means of through-and-through silver wire sutures. The two fatal cases of wound disruption occurred in association with general peritonitis in the terminal stages of that disease.

Pulmonary complications while not the most common complications of the postoperative period were nevertheless responsible for the largest number of deaths, and were found to be the chief cause of death in 16 of the 24 deaths following the one stage operation. It is our belief that most cases of postoperative bronchopneumonia develop on the basis of pulmonary atelectasis, and we are convinced that energetic treatment of the latter condition will minimize the incidence of pneumonia. Preventive measures are most important and accordingly patients should have frequent changes in position during the first few hours after return from the operating room. Care should be taken to see that abdominal dressings are not tight enough to embarrass respiration, and morphine should be prescribed cautiously in order to avoid respiratory depression and abolition of the cough reflex. Deep breathing is encouraged, carbon dioxide inhalations being resorted to if necessary. In case retention of bronchial secretions occurs special nursing care is of great value since patients must be made to cough frequently. Tracheo-bronchial suction has proved to be of the ut-

most importance in many cases, whereas a small number of patients require bronchoscopic aspiration. There are few fields of surgical endeavor in which greater rewards are obtained than in these preventive measures against postoperative pulmonary disease.

Pulmonary embolism accounted for 5 of the 24 postoperative deaths and remains one of the most distressing problems in abdominal surgery. In none of these cases was clinical evidence of thrombophlebitis or phlebotrombosis of the leg veins recorded prior to death. More recently during the postoperative period the lower extremities of every patient are watched with the greatest care following the suggestions of Allen, Linton and Donaldson, and femoral vein interruption is carried out promptly when the indications for this procedure are present. Thus far the results seem promising. Furthermore it is to be hoped that future advances in the understanding and use of heparin and dicoumarin may serve to reduce the incidence of this dreaded complication.

Complications referable to the genitourinary tract were quite frequently encountered but fortunately were not a common cause of death. One death was due to septicaemia which was thought to have had its origin in the urinary tract. Urinary tract infections are distressing and often recalcitrant to treatment. As previously mentioned this is ordinarily not due to a neurogenic disorder of the bladder since the nervous mechanism of the bladder has been demonstrated repeatedly to be intact following operation. Undoubtedly the act of micturition is somewhat disturbed and impeded due to lack of the support ordinarily afforded by the rectum and perirectal structures but may be expected to return to normal with the closure of the perineal wound. A number of the male patients with incipient prostatic development develop clinical manifestations of this disease during convalescence or later. Transurethral resection when indicated has yielded excellent results in such cases. There were 2 cases of perineal urinary fistula. In this complication was noted early in convalescence and was presumably due to injury to the ureter or in involvement of it by neoplasm, since the pelvis was filled with a large tumor mass at the time of operation. It was hoped that spontaneous

closure of the fistula would occur as the perineal wound filled with granulation tissue. Such was not the case and a severe upper urinary tract infection later developed which required nephrectomy, and this resulted in prompt subsidence of symptoms. In the second case the ureter was accidentally divided at the time of operation and repaired over a ureteral catheter. Several weeks later the urinary fistula developed and in the absence of renal infection was treated conservatively.

Of the less common complications may be mentioned parotitis, transfusion reactions, slough of the colostomy, thrombophlebitis, inadequately explained convulsive seizures in one patient, functional ileus and intestinal obstruction. Adynamic ileus was most unusual, this in all probability being due to the common use of the Levine tube with Wangenstein suction during the first few postoperative days. By providing a vent in the colostomy at an early date troublesome distention and gas pains may be largely eliminated. There were 7 instances of mechanical small bowel obstruction. Three of these required enterostomy while the remainder were overcome by means of suction with the Miller-Abbott tube.

SUMMARY

In comparing the present series of cases with the series previously reported, we find definite although not striking, improvement on several scores. The operability has increased due to earlier diagnosis and an extension of the limits of operability in cases in which the disease is more advanced. The latter has become possible due to standardization of the operative procedure and improvement in preoperative and postoperative management. The operative mortality has been lowered in spite of greater operability. Surgery remains the mainstay in the treatment of cancer of the rectum and rectosigmoid, and all methods other than

radical removal of the diseased tissues may be expected to result in a high percentage of recurrences. In some patients unfit for radical procedures due to physical defects, operations have a place in the field of treatment. Surgical diathermy, x-ray and radium are to be regarded as forms of palliative treatment. With added experience we believe that for most patients the one stage combined abdominoperineal resection is the procedure of choice. It seems improbable that great improvement in the future can be expected from more radical operations in patients with far advanced or incurable disease, but that better results will come most importantly from earlier diagnosis and earlier treatment and second from a better understanding of and consequently, the prevention and better management of such postoperative complications as pulmonary embolism, wound sepsis, and those complications arising in the genitourinary tract.

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PROLONGED INTUBATION SUCTION AND DEFERRED OR DELAYED SURGERY IN TREATMENT OF MULTIPLE ADHESIVE OBSTRUCTIONS OF THE SMALL INTESTINE

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CLINICAL and experimental studies have greatly improved the treatment of intestinal obstruction. Prompt surgical intervention coupled with decompression has remained the most effective method of management in patients with acute obstructions who present evidence of peritoneal irritation or bowel strangulation. The development and improvement of the intestinal intubation decompression technique has made possible the relief of occasional simple acute mechanical obstructions without surgery. Technical difficulties encountered in the surgical treatment of patients obstructed by postoperative or inflammatory multiple adhesions have furnished a strong stimulus for the further utilization of these nonoperative methods. The dangers of delaying surgery by the employment of nonoperative methods were recognized and emphasized in early surgical history. Recent surgical literature recommends that if progressive decompression is not noted within 24 to 48 hours laparotomy should be performed.

This report is stimulated by the successful treatment of multiple small bowel obstructions by continued nonoperative decompression under circumstances that would have made surgery difficult. The authors do not propose to abridge the rule that operation should be prompt if decompression is delayed. They wish simply to present for consideration the possibility that in exceptional instances prolonged efforts at decompression by intestinal intubation might be effective. Similar experiences have been encountered by other surgeons but these have not to the authors knowledge been emphasized in the literature. Since the development of the modern methods of treatment of intestinal obstruction has a

definite bearing upon this subject, the literature will first be briefly reviewed. The records of 7 patients who presented interesting management problems will then be presented and discussed.

THE DEVELOPMENT OF THE MODERN SURGICAL TREATMENT OF INTESTINAL OBSTRUCTION

The current methods of treatment of intestinal obstruction have been the outgrowth of a long period of development of ingenious therapeutic devices. Earlier treatment was largely medical and with little success. Abercrombie (1830) giving an excellent description of the symptoms and postmortem findings in various types of obstruction, lists the aids in treatment as blood-letting, tobacco injections or infusions, application of cold to various body surfaces, cautious use of purgatives, oral administration of 1 or 2 pounds of crude mercury and then if the patient appears to be sinking free use of stimulants. Occasional feeble efforts at surgical treatment are mentioned. Dujardin Beaumetz (1886) discarded the use of mercury because experiments had shown that it did not descend in bulk but rather penetrated slowly globule after globule. The forcing of water, Seltzer water or air through rectal tubes into the colon was described. The efficiency of the ileocecal valve that plays such an important rôle in modern treatment was emphasized. Milder purgatives were recommended. As a last resort puncture through the abdominal wall and aspiration of distended loops of bowel were employed. The use of the rectal excitator which dates back to 1816 and which employed faradic or galvanic current between the rectum and the abdominal wall was favorably considered. He then adds that when the vomiting has been quieted by food drinks, the pain alleviated by subcutaneous morphine

and all the resources of medical therapy have been exhausted, the interference of the surgeon is demanded.

The introduction of anesthesia in 1846 and antiseptic surgery in 1867 brought the surgical treatment of intestinal obstruction into general use. A lack of understanding of proper methods of preparation and management of patients resulted in an appalling mortality. As late as 1889, in discussing surgery for intestinal obstruction, Senn recognized that many physicians refused to consider it. The clinical studies of Ashhurst and Schramm (quoted by Senn), Curtis, Naunyn, Senn, and others definitely establish the value of early laparotomy in the treatment of intestinal obstruction.

A multitude of experimental studies has paralleled and influenced this surgical development. Crowl and Johnston, Blodgett, Wangenstein (41), and others have recently reviewed them. The major developments have been recognition of the importance of chloride and protein replacement and hydration (3, 17, 18); the importance of circulating blood volume replacement by blood or plasma in the treatment of shock (5, 14, 35); the late role of toxic absorption from distended devitalized loops (10, 19, 31, 32, 40, 41); the importance of a high concentration of oxygen in relieving distention (15); the use of modern anesthetic agents, and above all the recognition of the importance of intubation decompression

THE DEVELOPMENT OF INTESTINAL INTUBATION

Gastric and later intestinal intubation techniques were originally developed for research and diagnosis. John Hunter (1793) introduced a flexible stomach tube for artificial feeding. Mathieu describes six types of tubes used for stomach examination. Aspiration, although seldom employed, was accomplished by several means. One was the attachment of the open end of the stomach tube to the first of two communicating flasks, the second flask being filled with water and placed at a lower level than the first. This is the method now commonly used. Credit for the introduction of gastric lavage as a means of therapy in intestinal obstruction is usually given to Kussmaul and Cahn (1884). These authors

and later Rehn maintained that suction irrigation emptied the stomach of its contents and also evacuated a certain portion of the upper intestinal canal above the site of obstruction. Westermann (1910) and Kappis (1911) introduced continuous siphonage drainage of the stomach in the clinical treatment of peritonitis. Ward (1925) recommended suction rather than siphonage drainage in peritonitis. The earlier gastric intubation devices rarely entered the duodenum. Levin (1921) introduced the nasal catheter duodenal tube commonly employed today. Wangenstein (42) years later, employing a modified duodenal tube, reported successful suction drainage treatment of selected patients with simple or with postoperative adhesive obstructions without surgery, and by a long series of chemical and experimental studies reintroduced and popularized the principles of bowel decompression. The possibility of deep intestinal intubation suction was foreshadowed by Scheltzema (1908), Einhorn (1919), Buckstein (1920), and McClendon and Medes (1925) when they introduced flexible tubes into the small intestine to study bowel physiology and to instill medication or barium. Miller and Abbott (1934) devised the convenient balloon tipped intestinal intubation tube that is now commonly employed.

AN EVALUATION OF INTESTINAL INTUBATION AND SURGERY IN SMALL BOWEL OBSTRUCTION

Abbott and Johnston (2) (1938) first used the Miller-Abbott tube in the suction decompression treatment of small bowel obstruction. Thirteen of 16 patients with obstruction were intubated. Relief from symptoms and distention occurred within 24 hours. Operation was performed upon 5 of these patients. Barium was employed for diagnosis in 6. Since this time the Miller-Abbott tube has been widely used in obstruction, and numerous reports have accumulated in the literature. Johnston (1940), Crowl and Johnston (1941), and Noer and Johnston (1942) have reviewed their experiences. Three hundred and thirty-two patients were treated. Gastric suction was employed in 53 cases, duodenal in 39, and

intestinal intubation in 180. The authors are of the opinion that the intubation treatment was of great value in avoiding operation in many patients and in relieving distention before surgery in others. Operation was carried out within 24 hours when mesenteric vascular interference was suspected or when patients were seen before marked distention. The authors report an overall mortality of 10.9 per cent and feel that the use of suction drainage particularly intestinal intubation was largely responsible for this low figure. Abbott (2) (1941) reviewed the diagnostic, experimental and therapeutic uses for the Miller Abbott tube and illustrated its value as an aid in the surgical treatment of intestinal obstruction. Sixteen patients with paralytic ileus were treated with 3 deaths. Seventy-four patients with mechanical obstructions of the small intestine were treated with 5 deaths. Twenty-seven patients with peritonitis and obstruction were treated with 6 deaths. Leigh and co-authors (24, 25 in 1940 and 1942) combining the use of the Miller Abbott tube with surgery in most patients, report 77 paralytic obstructions with a 6.9 per cent mortality and 132 mechanical obstructions with a 4.6 per cent mortality. Three of their earlier reported patients required 3, 5 and 7 days, respectively, before decompression was obtained. Much more prolonged conservative treatment was carried out in the case of the occasional patients with obstruction and peritonitis.

Schlicke, Borgen and Dixon report the results of conservative treatment in 45 patients with simple small bowel obstruction as complete relief in 23 and partial relief in 10. Five patients were discharged without operation because of complete relief. Emergency decompression was required in 8. Elective surgical procedures were performed in 3. These authors feel that in low grade obstruction the amount of time spent with conservative measures is optional but that in high grade obstruction without improvement surgery should be performed within 2 to 24 hours. Blodgett (1942) reports death in 8 of 56 patients with mechanical intestinal obstruction treated without intestinal suction. Nineteen patients were then treated with intestinal suction, with

1 death. He summarizes the mortality statistics of other authors and reports an average mortality reduction from 13 per cent without intestinal suction to 7.9 per cent with intestinal suction. Glenn (1941) reports in testinal intubation treatment of 35 patients with mechanical obstruction with 6 deaths. In 11 of these patients, no surgery was carried out.

McKitttrick (1941) reports a greatly decreased mortality in the treatment of small intestine obstruction since the use of the Miller Abbott tube. It was employed in 20 patients and reached the small bowel in 10. All but 1 of the patients were operated upon. Early operative intervention in patients whose obstruction history is not longer than 24 to 48 hours was employed. Wangenstein (41 in 1942) emphasizes the importance of decompression by suction drainage of the stomach and the small bowel in the relief of distention, and in preparation for surgery. The mortality rate from the treatment of obstruction of the small intestine he believes will be further lowered by improvement in surgical care and technique including the use of aseptic anastomosis and enterostomy (43). The danger of delaying surgery in patients with strangulation obstruction by prolonged use of intubation was strongly emphasized. Dennis and Brown have more recently summarized the work at the University of Minnesota. Supportive therapy and constant suction through a Wangenstein or a Miller Abbott tube was started on all distended patients. If the tube failed to pass into the small bowel within 48 hours or if satisfactory decompression was not obtained a catheter enterostomy was then performed. If subsequently the obstruction failed to relax, elective exploration was undertaken. Patients with signs of peritoneal irritation were explored regardless of the degree of distention. These authors report 110 recently treated obstructions. Successful conservative therapy was employed with the Wangenstein tube in 13 patients and with the Miller Abbott tube in 1. The Miller Abbott tube is now used routinely on all cases of obstruction of the small intestine. In most instances it is used by these authors as an aid to surgery.

EVALUATION OF INTESTINAL INTUBATION AND SURGERY IN MULTIPLE ADHESIVE OBSTRUCTION OF SMALL INTESTINE WITH A PRESENTATION OF 7 ILLUSTRATIVE CASES¹

Review of the literature has demonstrated the advantage of decompression by gastric and duodenal suction or by Miller-Abbott tube intestinal intubation. The mortality from all varieties of intestinal obstruction has been greatly reduced by decompression and by improvements in supportive therapy and surgical technique. Each variety of obstruction and each patient with obstruction presents an individual problem. The time period that may be discreetly employed in an attempt at decompression will vary with circumstances. Surgery should be readily employed when the symptoms and findings suggest compromised viability of bowel. Surgery is also frequently indicated after an obstruction has been relieved by conservative means in order that the pathology be accurately determined.

There are instances, however, in which a history of inflammatory disease or earlier surgical exploration has given presumptive evidence that the obstruction is produced by multiple adhesions. Such adhesions frequently produce several points of high grade obstruction. When the obstruction becomes complete at one point bowel distention may effect complete obstruction at one or several other constricted areas. Since surgery other than enterostomy under these conditions carries a definite operative risk and frequently enhances the pathological process, and since the high grade obstructions will at times relax spontaneously, it is the impression of the authors that a prolonged and occasionally a repeated trial at conservative therapy may be warranted. This continued conservative treatment may be controlled by the condition of the patient and rapidly supplemented by surgery if symptoms and findings suggest compromised viability of the bowel. It cannot be controlled by any arbitrary fixed time limit. This statement will be supported by the presentation of 7 patients selected from a large group of multiple small bowel intestinal

obstructions to illustrate the use of prolonged intubation suction and deferred or delayed surgery.

CASE 1 N S This 36 year old white married female had been under treatment for 11 years because of a slowly progressive nonspecific ulcerative colitis. Repeated x-ray examinations had shown ulceration and narrowing in the descending and sigmoid colon. Repeated proctoscopic examinations demonstrated extensive rectal and sigmoid ulceration. Ileostomy or colostomy had been advised and refused. One month before the present admission the symptoms of nausea, diarrhea, and abdominal and rectal pain became more severe. Two weeks later a rectovaginal fistula developed. Progression of these symptoms and loss of strength and weight finally led the patient to consent to a colostomy. Exploration through a rectus incision revealed the ascending and the greater portion of the transverse colon to be grossly normal. A transverse loop colostomy was established through an upper mid-line stab wound. Colostomy drainage was copious but remained thin. On the 7th postoperative day bulging through the rectus incision suggested separation of the deeper layers. Three days later persistent nausea and cramping abdominal pain necessitated an abdominal x-ray examination which revealed no bowel distention. Barium injected through the colostomy filled the right colon and terminal ileum. Vomiting then developed and 3 days later colostomy drainage stopped and abdominal distention began. The roentgenogram revealed marked dilatation of numerous loops of ileum. A Miller-Abbott tube was passed and entered the jejunum within 12 hours. The abdomen, although markedly distended, was not tender. Roentgenograms during the following 48 hours revealed a slight increase in the diameter of the distended loops. Barium injected through the Miller-Abbott tube failed to pass onward and was aspirated. Operation was accordingly advised. In the operating room, during the positioning of the patient several hundred cubic centimeters of watery, light brown fecal material ran through the colostomy opening. The patient was returned without operation and suction through the Miller-Abbott tube, enemas, and positioning of the patient were continued. The following day the dilated loops which lay ahead of the Miller-Abbott tube were slightly less distended. During the next 4 days clinical and x-ray evidence of distention remained the same (Fig 1). Abdominal examination elicited no marked tenderness. Nine days after the first intestinal intubation the Miller-Abbott tube passed through the highest point of obstruction and progressive decompression began (Fig 2). X-ray examination 6 days later revealed one moderately dilated loop in the lower left quadrant. Enemas then began to return definite fecal material and spontaneous colostomy drainage occurred. Eighteen days after its insertion the Miller-Abbott tube was removed. During the period of

¹ Acknowledgment is expressed to Dr. Deryl Hart, Dr. Durward L. Lovell and Dr. Warner Wells for the use of the histories of 3 of the patients selected as illustrative cases in this report.

Intubation adequate fluid replacement, frequent blood transfusions, and adequate vitamin supplement are given. The patient has been followed 8 months without recurrence of obstruction or distention.

This case illustrates the longest period of time employed by the authors between the intestinal intubation and the development of definite symptoms of progressive decompression. Such persistent efforts at suction decompression without the additional aid of an enterostomy could be justified only under unusual circumstances. If employed continuous observation for signs of intestinal strangulation or impending perforation is necessary. The record is presented because it illustrates the difficulty of determining any definite period of time beyond which conservative management must be supplemented by surgery.

CASE 2 H W. This 51 year old white male weighed 305 pounds. Fifteen years before admission his urinary bladder was ruptured during an automobile accident. Following surgical repair urinary and fecal drainage through a lower abdominal wound persisted for six months. Ten years before admission he received several shotgun wounds about the right hip and lower abdomen. Between that time and the present admission pale stools vomiting occurred on several occasions after overeating. Four days before admission he ate an unusually large meal. Three hours later acute cramping midepigastric pain developed. Symptoms persisted and he was referred to the medical service with tentative diagnosis of acute cholecystitis. Examination revealed a lower abdominal wall that was largely replaced by dense scar tissue defect. Some generalized abdominal tenderness was present. An x-ray film of the abdomen showed no visceral detail because of the obesity and faulty technique. During 3 days of medical observation vomiting, distention, and increased abdominal tenderness persisted. Enemas returns contained little fecal material. Roentgenogram at this time showed distention of several loops of small intestine (Fig. 3). A barium enema filled the colon with barium. Intestinal intubation was begun. Ten hours later the tip of the tube lay in the upper jejunum. At this time the poor management was further complicated by the feeding of routine barium meal ordered earlier by error. Some of this barium was successfully aspirated through the suction tube and some of it entered and visualized the proximal distended loop. The tip of the Miller Abbott tube had followed the barium into the proximal dilated loop within 5 hours. There it remained arrested with large distended loops of barium filled small bowel beyond it. Some of the barium passed on through these distended segments in the next 4 hours to reach the colon (Fig. 4). Suction was continued 4

more days during which time some flatus and small amount of fecal material passed with repeated enemas. Distention by this time as well relieved. The suction was clamped off and since the patient tolerated liquids and a soft diet well the tube was removed. Three days later he was discharged with instructions that soft or liquid diet be continued for at least 1 month. During the period of the next 3 months he experienced no symptoms of abdominal discomfort.

This patient because of the scarred abdominal wall and marked obesity would have been a difficult technical problem for surgical treatment. His obstructive symptoms were intermittent but progressive over 7 days until he presented marked distention and a moderately tender abdomen. Intubation was successful in reaching and decompressing only the proximal loop of distended intestine. Continued suction maintained over a period of 6 days allowed the remaining partially obstructed loops of small bowel to decompress themselves so that by the 7th day the patient could eat a liquid diet and continue regular bowel movements. This record also illustrates the difficulty of determining the degree of obstruction by x-ray evidence of small bowel distention. A portion of the barium meal given by error early in the suction treatment traversed several distended loops and reached the cecum within 24 hours. Decompression of these loops was complete 4 days later.

CASE 3 G B. This 37 year old white male had an appendectomy 5 years before admission. Severe cramping abdominal pain associated with nausea, vomiting and distention developed. He was referred to this hospital 36 hours later. Examination revealed marked distention and tympany, moderate periumbilical tenderness, and definite borborgymus. An abdominal x-ray film demonstrated several loops of dilated small intestine (Fig. 5). A Miller Abbott tube was passed within 4 hours. At 36 hours it had progressed 11 ft to the jejunum and had effected decompression of 11 but one of the distended loops. The tube although it remained arrested in the right upper quadrant, was kept in place 4 days with continued suction (Fig. 6). During this time liquid oral feedings were given and gas passed regularly through the rectum. Two days later the distended loop of bowel beyond the arrested Miller Abbott tube decompressed spontaneously. Thin barium injected through the tube reached the cecum within 7 to 12 hours. Suction was discontinued. When the patient left the hospital he was tolerating liquid diet well. He has since eaten regular diet for a period of 5 months without difficulty and has gained 35 pounds in weight.



Fig 1 Case 1 Distended loops of small bowel beyond arrested Miller Abbott tube 5 days after intubation. These loops have remained approximately the same size since intubation. The barium in the cecum is a residual of the colostomy barium enema.



Fig 2 Case 1 Advance of the Miller Abbott tube 9 days after intubation showing for the first time some definite decompression of the distended small bowel. Decompression and relief of the obstruction were complete 6 days later.

This case represents an acute obstruction occurring 5 weeks after an appendectomy with relief of the major portion of the distention within 36 hours. One loop of small bowel beyond the tip of the Miller-Abbott tube remained partially distended 6 additional days and then collapsed spontaneously. During this period of time oral feedings were given and gas passed regularly through the rectum. This observation confirms the conclusion made in the discussion of Case 2 that a loop of small bowel although distended, may permit the passage of intestinal content.

CASE 4 W. B. This 27 year old male was readmitted 3 days after an appendectomy. Bowel movements and gas passage had diminished during 3 days and then stopped entirely. Severe cramping abdominal pain developed 14 hours before admission. Examination revealed abdominal distention and tenderness. Intestinal borborygmus was present during the cramping pains. An abdominal x-ray picture revealed one moderately distended loop of small bowel. Intestinal intubation was accomplished

within 24 hours. Distention was relieved during the next 48 hours and the tube was removed. The patient tolerated a soft diet, passed gas readily, and 2 days later had a natural bowel movement. There has been no recurrence of symptoms of obstruction in 14 months.

This case represents an early mild post-operative adhesive intestinal obstruction that responded quickly to intestinal intubation and suction employed in the conventional manner.

The first 4 case histories illustrate the conservative relief by intubation suction of multiple small bowel obstructions produced by postoperative or inflammatory adhesions. The variations, both in the severity of the obstruction and in the duration of the suction intubation preceding decompression, support the opinion that conservative management may be limited only by the developments encountered in the individual patient. Symptoms of compromised bowel viability demand immediate surgery. Failures either in the introduc-



Fig. 3. Case Loops of distended small intestine protrude 7 days after the onset of obstructive symptoms in 305 pound patient.

tion of the tube or in suction decompression after intubation may also require surgery. The importance of surgery in the treatment of intestinal obstruction is fully recognized. The principles governing the conventional use of emergency surgery have been developed in the literature review and will not be amplified. The principles governing the use of elective surgery after successful intubation decompression will be illustrated by 3 histories.

CASE 3. C. D. This 58 year old fat woman admitted 3 years ago complaining of cramping abdominal pain and occasional nausea and vomiting lasting 3 weeks. Ten years earlier hysterectomy had been performed and followed in 3 years by cholecystectomy and appendectomy. Ten years ago symptoms of partial intestinal obstruction led to exploration and diagnosis of anastomotic stenosis. The patient remained relatively free from obstructive symptoms until the present attack.

Examination revealed moderately distended abdomen with old operation scar and small ventral hernia. Roentgenogram confirmed the diagnosis of small bowel obstruction. Intestinal intubation was accomplished. Suction relieved the distention in 3 days. A barium-ray study was then



Fig. 4. Case 2. Arrest of the Miller-Abt tube 37 hours after introduction. Barium has evidently passed 24 hours earlier, making one distended small bowel loop. Some of the barium has reached the colon.

interpreted as demonstrating complete obstruction. A laparotomy was performed. Several dense adhesions located approximately feet above the ileocecal valve were divided. The ventral hernia was repaired.

During the next 3 months numerous mild attacks of cramping abdominal pain occurred. One of these attacks became progressively more severe during 48 hours and the patient returned with tender distended abdomen. Suction intubation as readily accomplished and the distention again relieved in 3 days. Symptoms subsided for 7 months and then recurred mild intermittent attacks. Six months later severe attack lasted 48 hours and brought her into the hospital. The distention and cramping pains were readily relieved by suction intubation but recurred twice after removal of the tube. It was only after the third intubation, continued 24 hours, that obstructive symptoms subsided.

The patient for 3 months experienced series of episodes of minor bloating pain and distention. She then returned with obstructive symptoms lasting 5 days. Moderate distention demonstrable by examination and by ray. Intubation again relieved in 2 days. Mild bloating pain persisted 4 months and then another severe attack lasted 48 hours. Intubation during the first 3 days of this hospital admission accomplished relief of symptoms. Another exploratory laparotomy achieved no definite results either or not. Lateral anastomosis could be performed. Adhesions are present throughout the abdomen with approximately 8 feet of the terminal ileum firmly adherent to an extensive thickening of the process. Many adhesions were divided and small ventral hernia again repaired. Freedom from symptoms continued through the 5 months that have now elapsed since this procedure was carried out.



Fig 5 Case 3 Numerous distended loops of small intestine 36 hours after the onset of symptoms of intestinal obstruction and 5 weeks after appendectomy had been performed

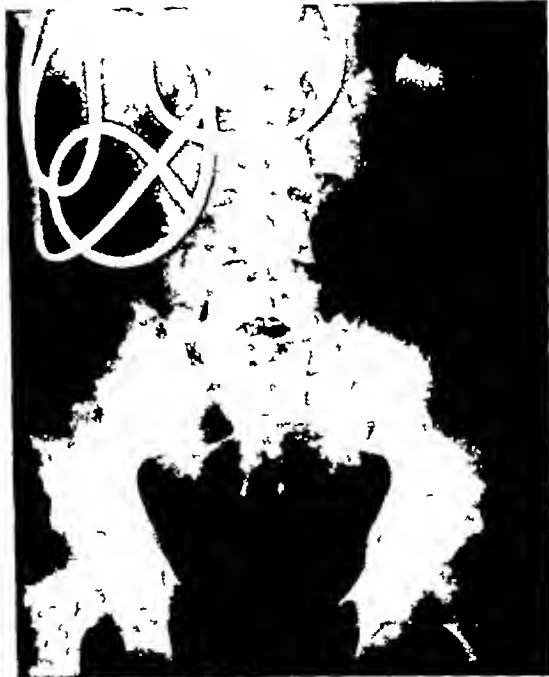


Fig 6 Case 3 Arrest of the Miller-Abbott tube 4 days after intubation. Relief of distention had been accomplished within 36 hours in all but one of involved loops of small bowel. This decompressed spontaneously in 48 hours

This patient illustrates well one of the most difficult problems encountered in bowel surgery. Surgery alone, intubation alone, and a combination of intubation and surgery have all been used in treating her various attacks of obstruction. The patient was decompressed by intubation seven times. Each of the three operations revealed an increase in the extent of involvement of bowel or adhesions. Each operation probably also contributed toward the formation of more adhesions. Resection or lateral anastomosis should have been performed during the first or second exploration. Conservative treatment of subsequent obstruction will be continued in the case of this patient if it is possible.

CASE 6 L B This 52 year old white woman had first developed a small ventral hernia after an appendectomy 14 years ago. A supravaginal hysterectomy was performed and a repair of the hernia attempted a year later. The hernia recurred and gradually increased in size. Four years before the present admission the hernia was successfully repaired.

Three years later attacks of cramping abdominal pain, vomiting, and distention began. The first lasted 1 week, and 1 month later a second lasted 4 days. Both were relieved in another hospital by suction through a duodenal tube. Four months later an attack became steadily more severe during 12 days, and she was referred to this clinic. Distention and hyperactive small bowel peristalsis were evident. X-ray examination revealed many loops of distended small bowel. A faintly calcified curved sausage-like mass of undetermined etiology was demonstrated in the pelvis. The tip of the intubation tube reached the upper jejunum in 12 hours. Decompression occurred in 3 days and 1 day later diagnostic barium was injected (Fig 7). It passed on into the colon without difficulty. Clear liquid feedings were well tolerated, and the patient was discharged.

Symptoms of cramping abdominal pain recurred and brought the patient back in 5 days again distended. Decompression with a Miller-Abbott tube was easily accomplished. Exploration was advised because of the increasing frequency of the attacks and the x-ray evidence of a foreign body. Numerous firm fibrous adhesions matted the ileum and lower jejunum together. The upper jejunum was moderately dilated. The operator freed many of the adhesions and resected one doubly linked portion

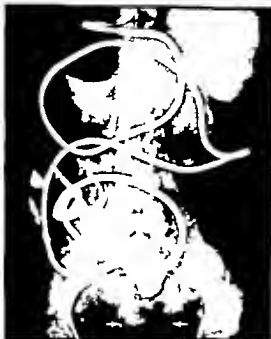


Fig. 7. Case 6. Successful decompression of small bowel 4 days after intubation in patient with postoperative obstruction. Barium visualizing the ileum at the tip of the tube passed in the colon readily. Arrows indicate partially calcified mass demonstrated later by operation to be beasar.

of the upper ileum. A firm, light, curved mass measuring 3 centimeters in length and 3 centimeters in diameter was located. The lumen of the lower ileum not removed. The exact origin of this beasar could not be determined. This patient has now remained free from obstructive symptoms 6 months.

This history illustrates the relief of two attacks of intestinal obstruction by suction through a duodenal tube and two by Miller-Abbott tube intubation. The increasing frequency and severity of attacks and the x-ray demonstration of a foreign body made elective exploration advisable. An intestinal beasar was removed and a doubly kinked, severely constricted segment of ileum was resected.

CASE 7. A P. This 65-year-old, but otherwise healthy, female patient had been complaining of nausea and occasional vomiting for 4 weeks and severe abdominal cramping pains for 10 days. For 4 years prior to the onset and one operation had been removed. Mild attacks of nausea, vomiting, and abdominal pain began 5 years ago, did not recur, and progressed at shorter intervals. She had explored 1 other bow-

el 4 months before this admission and several adhesions were divided.

Examination revealed moderately distended abdomen. I testinal borborrygmus as present. An abdominal x-ray picture demonstrated moderate dilatation of several loops of small intestine (Fig. 8). I testinal intubation was readily accomplished. Suction continued for 3 days. At the end of each time one small loop of terminal ileum remained distended. I fected hypoderm failed to advance but this loop or it reach the cecum (Fig. 9). Exploration was deferred. Firm adhesions bound together almost the entire length of the small intestine. One acutely kinked mass of adherent small bowel exposed in the right lower quadrant. Dilatation prevented above and collapsed bowel led from it. An ileocecostomy performed. The Miller-Abbott tube was removed 8 days later. This patient has now been relatively free from symptoms during the 3 years that have elapsed since operation.

This case history illustrates well the occurrence in a generalized adhesive process of a local area of severely kinked bowel that may give symptoms for many years and that frequently cannot be relieved by intestinal intubation or by simple division of adhesions. This form of obstruction is best treated by resection or lateral anastomosis. Recognition of this type of pathology before exploration is difficult. Individual judgment must determine whether patients with rapidly recurring attacks of obstruction should be explored after partial decompression as in this patient or subjected to more prolonged and repeated efforts with intubation therapy. If elective exploration is contemplated the preoperative decompression may well be left incomplete and the residual partial distention used as a guide to the most troublesome point of obstruction.

SUMMARY

The management of patient with multiple postoperative or inflammatory adhesions obstructing the continuity of the small intestine is difficult. The reviewed literature has covered many of the advantages of suction decompression therapy in all varieties of small bowel obstruction. In general patient who present symptoms of a strangulating obstruction are explored immediately. Decompression is employed only during the short time required for preparation for operation, or as an aid to postoperative management. Pa-



Fig 8 Case 7 Distended loops of small intestine present 24 years after a transabdominal hysterectomy, 4 months after exploration for small bowel obstruction, 24 hours after recurrence of symptoms of acute obstruction The Miller Abbott tube is seen to be entering the duodenum



Fig 9 Case 7 Extensive decompression 3 days after intubation One loop of terminal ileum remains dilated Lipiodol injected through the tube demonstrates a complete obstruction An exploratory laparotomy was performed

tients with so called mechanical obstructions and without evidence of strangulation have been treated by varying combinations of conservative management and surgery. The trend of opinion seems to be swinging toward exploration within 24 to 48 hours unless intestinal intubation has instituted progressive decompression. Occasionally patients decompressed conservatively have then undergone elective exploration to determine the etiology of the obstruction.

This report has been stimulated by the impression of the authors that certain patients, in whom a previous operation or abdominal inflammatory process has given presumptive evidence that the multiple obstructions present are a result of adhesions, may warrant longer or repeated trials of intubation decompression. They usually develop distention gradually and have occlusions that are less rigid and more amenable to conservative treatment than those encountered in other forms of in-

testinal obstruction. Surgery in these patients, unless resection or lateral anastomosis is possible, may fail to give lasting relief and may increase the number of adhesions. Temporary decompression either by ileostomy or by intestinal intubation has frequently allowed a spontaneous re-establishment of bowel continuity.

The length of time that may be safely spent in efforts at conservative management under these conditions has not been clearly defined. The chief danger of delay is damage to the circulation of distended loops and perforation. Toxic factors do not seem to play a rôle until viability is lost. Careful and repeated observations should give warning that the so called simple or mechanical obstruction is changing to the strangulation type. Immediate surgical intervention should then be indicated. If evidence of this misadventure does not appear, it is possible that high grade obstructions may undergo spontaneous decom-

pression even though distention may persist longer than the conventional 24 to 48 hours. Careful control of the state of circulation and nutrition of the patient by hematocrit or hemoglobin readings, and frequent determinations of chlorides, carbon dioxide combining power, plasma protein, and nonprotein nitrogen and adequate supportive and replacement therapy has made this prolonged conservative treatment possible.

The records of 7 patients that illustrate by the treatment employed various aspects of this problem have been presented. Prolonged treatment of persistent distention and obstruction as illustrated by the first patient is probably warranted only under unusual circumstances. Earlier decompression might have been achieved by supplementing the intubation treatment by an aseptic enterostomy. The 2d, 3d and 4th patients represent a more conventional form of prolonged conservative treatment in which the Miller Abbott tube is of unquestioned value. Case 5 illustrated the limitation and Cases 6 and 7 the value of combinations of intubation therapy and surgery.

CONCLUSIONS

Decompression by Miller Abbott tube in intestinal intubation and suction is an important therapeutic aid in the treatment of intestinal obstructions produced by multiple postoperative or inflammatory adhesion. Since the etiology of the obstruction can be determined by presumptive evidence many patients successfully relieved by conservative means will not require an elective exploration. Some patients relieved conservatively may require exploration because of recurring attacks. The period that may be expediently used in efforts at conservative decompression in this type of obstruction must be determined by the developments in each patient and need not be defined by a conventional time limit.

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PECTIN SOLUTIONS IN THE TREATMENT OF SHOCK

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SEVERAL macromolecular substances such as gum acacia, gelatin, and pectin, have been recommended for the treatment of shock or shock-like states. Gum acacia was chiefly used during the first World War (4, 10) but was later discarded because it was deposited in the liver, affecting the hepatic function (2, 13). Gelatin which was also introduced as a plasma substitute (4, 18), seems promising (16), although no extensive reports have as yet been published as to its use in the treatment of human shock. Hartman and his collaborators (7, 8) described pectin as a plasma substitute which they used in the prophylaxis of surgical shock and, in a few cases, in the therapy of shock, with promising results. Jacobson and Smyth demonstrated that the blood volume increases upon intravenous administration of pectin. In a recent publication we (15) were able to demonstrate that pectin is effective as a hemodiluting agent in human patients not in shock. In pursuing these studies, it seemed pertinent to investigate whether pectin solutions also produce hemodilution in patients in shock and, at the same time, to examine whether the intravenous administration of pectin improves the clinical condition of the patient.

Reduction of the circulating plasma volume, due to circulatory changes or to actual loss of plasma, has been recognized as an important factor in the mechanism of shock (17). Hemodilution with subsequent increase of the plasma volume is thus indicated in the therapy of shock.

MATERIAL

Sixty patients who were admitted to the hospital in, or developed after operation, a

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state of shock from various causes, constituted the material for this study. Table I lists the various types of shock and, at the same time, indicates the degree of shock. We have selected this method of grading for a better interpretation of the efficacy of pectin. This classification was useful also in another study (17).

Mild

1. Decrease in systolic blood pressure of not more than 30 millimeters of mercury, as compared with the preshock or postshock level
2. Increase in radial pulse

Moderate

1. Decrease in systolic blood pressure of more than 30 millimeters of mercury but less than 50 millimeters of mercury
2. Decrease in volume and quality of radial pulse with increase in rate
3. Diaphoresis

Severe

1. Decrease in systolic blood pressure greater than 50 millimeters of mercury
2. "Thready" radial pulse (120 per minute or more)
3. Cool moist skin
4. Restlessness

Profound

1. No measurable blood pressure
2. No radial pulse
3. Rapid respiration
4. Cold wet skin
5. Stupor
6. Cyanosis

METHODS

As soon as the diagnosis of shock was made, venous blood was drawn through the needle then used for the administration of the buffered pectin. The pectin solution was described as having an average micellar, or "molecular" weight of between 50,000 and 60,000. In Ringer's or sodium chloride solution the 15 per cent of pectin has a relative apparent oncotic pressure slightly greater than that of human plasma and a viscosity less than that of whole blood. Before adminis-

TABLE I.—TYPE AND DEGREE OF SHOCK IN 60 PATIENTS TREATED WITH PECTIN SOLUTION

Type of shock	Degree of shock			
	Mild	Moderate	Severe	Profound
Postoperative		20	3	
Trauma				
Hemorrhagic				
Medical		2		

tration the acid solution was buffered with sodium phosphate or sodium lactate to a pH of about 7.2

The blood was collected in a test tube containing 0.2 milligram dried heparin (liquamine Roche-Organon Inc). Sedimentation rate and hematocrit were determined in the same Wintrobe tube, the tube being centrifuged for 30 minutes after the rate of sedimentation had been observed for 1 hour. The sedimentation rate was not corrected for anemia. Hemoglobin was determined by the Sahli method by means of the photoelectric colorimeter (9). The density of the plasma, which is usually taken as an index of the plasma protein concentration was calculated from the specific gravity by means of the Barbour-Hamilton falling drop apparatus (3). Total protein nitrogen nonprotein nitrogen, and albumin nitrogen were determined by neutralization (14). Mean corpuscular hemoglobin concentration was calculated by the formula of Wintrobe (10).

Hemoglobin in gm. per 100 of blood
Volume of packed red cells per 100 of blood $\times 100$

After the infusion of pectin was finished and again 24 hours later samples of blood were drawn from the opposite arm and all findings were checked.

The results were subjected to statistical evaluation. The *t* value (5) indicates the statistical significance of the difference between pretreatment and posttreatment readings. *t* Values of 2.5 or over were taken as indicative of a significant difference.

$\bar{X}_1 - \bar{X}_2$
Mean of difference between observations before and after pectin administration
Standard deviation
are substituted for \bar{X}_1 , \bar{X}_2 , S , N before for \bar{X} , S , N respectively.

TABLE II.—THERAPEUTIC RESULTS FOLLOWING ADMINISTRATION OF PECTIN SOLUTION

Degree of shock				Remarks
Mild	Moderate	Severe	Profound	
		1		Pectin alone relieved shock permanently
				Shock relieved by pectin, blood given for anemia other than shock (anemia, loss of blood)
				Shock not relieved by pectin (PCT) but relieved by blood or plasma
				Shock not relieved, needs surgery after diagnosis of ectopic tube lacer and patient survived
				Shock relieved but patient died of other causes
				Shock not relieved and patient died despite administration of blood or plasma in addition
Terminal cases				

RESULTS

1 Therapeutic effects. The therapeutic results obtained after one infusion of 1,000 cubic centimeters of pectin were listed according to the degree of shock (Table II). Pectin solution alone permanently relieved the majority of patients exhibiting not too severe types of shock. In a few cases because of anemia or blood loss blood was administered after the pectin infusion had relieved the shock.

In 2 cases of mild and 2 of severe shock the condition was not relieved by a single injection of pectin but was relieved by subsequent administration of blood. Of these 1 patient with hemorrhagic shock of mild degree and another with moderate nonhemorrhagic shock responded after the injection of 500 cubic centimeters of plasma. In 2 cases of profound shock one injection of pectin raised the blood pressure from zero to 75/60 and 70/40 respectively but 1,000 cubic centimeters of whole blood in one and 500 cubic centimeters of whole blood with 500 cubic centimeters plasma in the other respectively were all given before the shock was permanently relieved.

In 3 cases of mild shock no or only temporary relief was achieved but the patient survived. In 3 patients pectin improved the symptoms of shock but the patient died

TABLE III—DATA IN THE FATAL CASES

Degree and type of shock	Blood pressure mm Hg		Pulse per minute		Hematocrit %		Hemoglobin Gm %		Total protein Gm %		Nonprotein nitrogen Mg %		Cause of death	Interval between injection and death	Other therapy
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After			
Profound medical	0	0	0	0	58.5	47	16.7	13.6	9.19	7.38	53	73	Volvulus	6 hrs	500 cc plasma
Severe operative	0	142/115	104	94	65	15	8.5	7.1	6.12	6.46	121	112	Hemorrhage Nephrosclerosis	4 Days	1500 cc blood
Moderate trauma	80/56	106/10	150	110	37	32	1.4	11.5	6.0	5.31	34	2	Shock	24 hrs	500 cc blood
Severe operative	0	60/0	140	150	41	25.5	13.5	12.0	6.00	5.60	33	38	Peritonitis	12 hrs	500 cc plasma
Moderate medical	90/7	140/100	120	110	40	41	16.7	1.7	8.00	6.76	35	38	Perforated viscous peritonitis	5 Days	500 cc plasma
Moderate trauma	81/60	130/50	128	100	46.5	36.5	10.7	0.6	6.60	5.24	60	71	Cord injury	6 hrs	
Moderate medical	86/0	100/70	100	112	40	37	1.2	11.0	6.70	6.12	90	80	Unestablished	3 1/2 hrs	
Profound medical	0	0	100	100	51.5	46	17.5	16.4	8.08	7.24	150	115	Uremia	12 hrs	
Severe medical	64/0	50/0	144	0	34	31	11	0.6	7.14	6.53	71		Unknown	10 Min	
Severe medical	68/4	60/0	137	0	39	37	16.2	10.0	7.93	7.62	78	73	Aneurysm of aorta	6 hrs	
Severe medical	5/30	65/34	0	124	45	3	14.8	0.6	8.30	6.90	53	61	Bronchogenic carcinoma	2 hrs	

(*) Terminal cases

0—No obtainable blood pressure or pulse

later from the underlying disease in spite of additional blood or plasma transfusions (Table III), only one of them still in shock. In three cases, pectin was ineffective and the patients succumbed, despite administration of blood or plasma in two of them. In five terminal medical cases in a hypotensive shock-like stage, pectin did not influence the fatal outcome.

There was a total of 11 deaths among the 60 patients. In part this is explained by the inclusion of 5 terminal cases (Table III). The latter were selected earlier in this work, not with the hope of improving their clinical condition but to gain clinical experience with pec-

tin administration. In 8 of the fatal cases, nitrogen retention was present. A definite improvement in the shock-like state was produced in 3, before death occurred due to the underlying pathology. In the 5 remaining, blood or plasma transfusions were also ineffective. No untoward reactions to the administration of pectin occurred in any of the cases.

2 Influence of pectin upon clinical findings
The average improvement in systolic and diastolic blood pressure was statistically significant and sustained for at least 24 hours (Table IV).

Generally, a decrease of the average pulse rate was noted which was maintained for 24

TABLE IV—INFLUENCE OF PECTIN ON BLOOD PRESSURE AND PULSE OF PATIENTS IN SHOCK

	Average values prior to pectin administration	Average change immediately after administration of pectin	t value	Average change 24 hours after administration of pectin	t value
Blood pressure—Systolic	74 mm. Hg	+33 mm Hg	7.7	+47 mm Hg	8
Diastolic	43 mm Hg	+25 mm Hg	7.7	+35 mm Hg	5
Pulse	108 per minute	-8.24	1.7	-5.5	1.10

TABLE V.—BLOOD CHANGES IN SIXTY PATIENTS IN SHOCK, FOLLOWING ADMINISTRATION OF PECTIN SOLUTION

	Average values prior to pectin administration	Average percentage change immediately after administration of pectin	value	Average percentage change 24 hours after administration of pectin	value
Hematocrit	15%	-50		17	6
Hemoglobin	13 gm %			—	
Protein nitrogen	7.5 gm %		19		
Plasma density	1.020 gm %	8	3	-6	3.4
Nonprotein nitrogen	4.1 mean %	-3	7	1.97	

hours. The volume of the pulse improved in all cases which responded to therapy.

Temperature and respiration did not show any significant change following the use of pectin. Immediate rise of more than 3 degrees F. in temperature occurred in only 1 case, although in 5 cases such increases were seen 24 hours later. However the underlying pathologic condition could have accounted for the delayed fever.

The change in the skin from a cool clammy state to a warm dry one as a result of successful therapy, was impressive.

3 Hemodilution and effect upon erythrocytes. Following the administration of pectin the hematocrit dropped in all cases, the hemodilution being maintained for at least 24 hours (Table V). The hemoglobin readings followed a similar trend, but to a lesser degree and the 24 hour value approached somewhat the control level. The degree of hemodilution did not depend on the original state of hemoconcentration. Hemodilution was found even in 8 of the 11 fatal cases. The difference between the decrease in hematocrit and decrease in hemoglobin concentration which was constantly observed would point to an increase of the mean corpuscular hemoglobin concentration. Mean corpuscular hemoglobin concentrations were calculated for the individual subjects.

Their average increase of these means was slight but statistically significant immediately after the pectin infusion (Table VI).

The decrease of the total protein nitrogen equaled that of the hemoglobin whereas the plasma density decreased to a lesser degree. Increases in these factors were seen infrequently in the samples drawn immediately after giving pectin: the hematocrit rose slightly in 1 case, hemoglobin in 2 and the plasma density and protein nitrogen in 3 each. The 24 hour samples showed a more frequent increase in these factors: the hematocrit rose above control values in 3 cases, the hemoglobin in 7, the plasma density in 9 and the protein nitrogen in 6. Nevertheless the mean reduction of all factors discussed was statistically significant. The albumin/globulin ratio did not change significantly. The nonprotein nitrogen showed a tendency to drop, but the individual variations were too great to warrant considering this change significant.

The sedimentation rate on the average was elevated before treatment. This may be due to the underlying disease (Table VI). After pectin administration the sedimentation rate rose concurrently and remained elevated for at least 24 hours. The rise was proportionately less in those cases which had an unusually elevated rate to begin with. The

TABLE VI.—EFFECT OF PECTIN SOLUTION ADMINISTRATION ON SEDIMENTATION RATE AND MEAN CORPUSCULAR HEMOGLOBIN CONCENTRATION

	Average values prior to pectin administration	Average change immediately after administration of pectin	value	Average change 24 hours after administration of pectin	value
Sedimentation rate	3.0 mm. per hour	+		+0.7	
Mean corpuscular hemoglobin concentration	97	+		+0.4	3
Albumin/globulin ratio	7	-0.15		-0.05	0.05

rate of sedimentation was not affected by the subsequent administration of dextrose or saline solutions whole blood or plasma.

4. *Effects of repeated administration of pectin.* In 3 shock cases administration of pectin in 5 cc. contractions of pectin was repeated because the patients' clinical condition had not sufficiently improved. The hemodilution increased still further as did the sedimentation rate. The repeated use of the additional amount of pectin did not result in further improvement in any case.

5. *Patient 13.* This case had a possible pyrogenic reaction after pectin administration. Since, however, pectin was transferred from the original bottle into a hospital flask, the possibility of a secondary contamination could not be excluded in this instance. No other untoward side effects after pectin were noted nor did the veins at the site of administration show any tendency to thrombose. The administration of blood or plasma after pectin produced no untoward results.

DISCUSSION

Pectin solutions given intravenously produce hemodilution to a greater degree in patients in shock than in those not in shock as shown from a comparison of the data in this and a previous study (15). The degree of hemodilution can be measured from the hemoglobin or the protein nitrogen concentration. Actually the decrease of these two factors runs parallel. That the hemodilution is less marked in the plasma density is less marked is due to the fact that the pectin in the plasma increases the plasma density. The drop of the hematocrit is consistently more marked than that of the other factors. A possible explanation of this phenomenon is a shrinkage of the red blood cells. That may increase the hemoglobin concentration of the individual cell without raising its hemoglobin content. The latter becomes apparent when the mean corpuscular hemoglobin concentration is calculated.

This shrinkage might be related to the rouleau formation which follows pectin administration and which is indicated by the rise in sedimentation rate. If the sedimentation rate (due to hemodilution produced) were corrected for the decrease in the hematocrit, the

rise would appear less marked. Pseudocoagulation (rouleau formation) is produced by many macromolecular substances (6). Its occurrence has recently been stressed by Ivy and his co-workers as a contraindication to the use of such plasma substitutes for hemorrhage conditions. Pseudocoagulation reduces the initially small number of effective erythrocytes. Ivy and co-workers thought, furthermore, that pseudocoagulation may cause thrombosis in the capillaries. In our material in cases in which anemia or blood loss was never as marked as in the dogs of Ivy and his collaborators no clinical evidence of such phenomena was seen. We therefore do not feel justified in considering the rise in sedimentation rate (which does not exceed that seen in infections) as a contraindication to the use of pectin solutions in shock except in cases in which the patient is exsanguinated.

It is safe to assume that the hemodilution produced by pectin in patients with shock increases the plasma volume and that the latter phenomenon accounts for the beneficial effect of pectin solutions which is a striking and seen in every degree of shock. Even in moribund patients pectin produced hemodilution which indicates that even in a terminal stage pectin solution does not rapidly leave the circulation in appreciable amounts. In hemorrhagic shock, an improvement was noted but in this respect our experience is limited. Occasionally pectin was ineffective, an experience encountered in all degrees of shock, in some of these failures of pectin whole blood alone or blood and plasma relieved the shock. It is, however, possible that if an additional amount of pectin had been given, a similar successful result might have been obtained with pectin alone. The number of our failures is too small to draw any conclusion as to whether and to what degree plasma is superior to pectin solutions. It is obvious that pectin cannot substitute for whole blood, but our data point to its being capable of increasing the plasma volume in shock. Even if further comparative investigations would show it to be not quite so good as plasma pectin could still earn a place as a plasma substitute under emergency conditions, because it has definite hemodiluting effects without having untoward side effects.

The lowering of the protein concentration in the plasma following pectin infusion is no contraindication to its use since it is not the plasma protein concentration but the total circulating plasma protein that is of significance (1).

CONCLUSIONS

Pectin solutions produce marked hemodilution in patients with shock and are effective in its treatment as shown in 60 patients. No undesirable side effects were noted save the increase in sedimentation rate the significance of this increase in the nonexsanguinated patient is doubtful.

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SULFANILAMIDE ABSORPTION VIA THE RECTUM AND VAGINA

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THE purpose of this paper is to report a short study of the absorption of sulfanilamide from the vaginal and rectum when given as a single dose of the dry powder at the completion of operations on the

Previous to these studies made in May and June 1941 over a period of several years we had been giving 90 grains (5.8 gm.) of sulfanilamide powder in the rectum as the final procedure in hemorrhoid operation. We had also been placing a similar amount in the vagina upon completion of operations for total abdominal hysterectomy. The thought in each case was to decrease local infection in certain contaminated puerperal patients of lessening postoperative pain, inflammation and danger. In the cases of total abdominal hysterectomies it was thought that the danger of peritonitis and fascial plane infection would be decreased. We were not particularly interested in the amount of absorption of the drug as the abilities of both viscera in this regard were known for other drugs and studies had been and were being reported for the sulfonamides rectally.

Verh, Turrell and Marino (1) early in 1939 had reported that sulfanilamide was well absorbed from the colon of rabbits. The same group (2) reported 18 months later on the absorption of sulfanilamide from the rectum and colon of human beings, obtaining results not greatly different from those usually obtained by oral administration. The drug was given either as a 1 per cent aqueous solution or in glycerine suppositories at intervals of 3 or 4 hours. Ildward H. Wood reported similar results in 3 individuals receiving the drug in 0.8 per cent solution in tap water by rectum.

Recently we decided to check on the amount of sulfanilamide in the blood of those patients receiving the drug by vagina or rectum at the time of operation. If it were being absorbed it would mean that probably sufficient concentration was being obtained in the tissues at the site of operation to offer considerable protection against susceptible organisms. If it were not being absorbed, the probabilities were that it was of little benefit despite our clinical impression that the

postoperative course was smoother after its use.

Twenty-five consecutive patients were studied. Eight of the 25 had simple rectal operations for one or more of the following conditions: internal hemorrhoids, internal and moderate prolapse. Seventeen patients had vaginal operations of various degrees. Fifteen of the 17 had abdominal operations at the same time. Seven of these were total abdominal hysterectomies. At the completion of the rectal or vaginal operation 90 grains (5.8 gm.) of the dry sulfanilamide powder were placed in the rectum or vagina whichever had been the site of operation. Blood studies were begun 6 hours later and repeated daily until negative.

Reference to the chart will show that in general the highest concentrations of sulfanilamide in the blood were obtained in the first 24 hours. For the rectal cases it was obtained in the first 6 hours. The same would hold true for the vaginal cases also if the exceptional concentration of 60 milligrams in the 24 hour specimen of 1 patient were disregarded. This finding was not checked by the laboratory and is out of line with the other findings.

One thing noted early in the study was the variability of the blood levels in different individuals and in the same individual from day to day. Absorption was unevenly performed probably due to at least 2 factors: (1) loss of the drug by expulsion from the rectum or vagina before absorption and (2) lack of sufficient moisture at times to render the drug soluble. The variations in the second factor were probably responsible for many variations in the rate of absorption.

This was well exemplified by the only patient that showed no absorption. She expelled the powder from her vagina as a dry cake 2 days after the operation which consisted of cauterization of the cervix and cholecystectomy. With her it probably would have been wise to moisten the powder after introduction into a somewhat dry vagina.

SUMMARY

Twenty-five patients each received 90 grains (5.8 gm.) of dry sulfanilamide powder in a single dose at the site of a rectal or vaginal operation. All except 1 patient showed some absorption. The

TABLE I.—SULFANILAMIDE CONCENTRATION IN BLOOD AFTER SINGLE DOSE BY RECTUM OR VAGINA

Case No.	Wt.	Age	Time post	Course per	hrs. post	1 eq hrs.	days	days	days	days	days	days
2061	145			Rectum								
2062	144	8		Rectum								
2063	140	8		Rectum								
2064		6		Rectum			1	1				
2067	1			Rectum					1			
2068				Rectum						T		
2070				Rectum			T					
2071	70	1		Rectum		T						
Average rectal					1							
2074	106	8		Vagina	1							
2075	11	1		Vagina	T							
2077	106	8		Vagina								
2078	10	8		Vagina		6						
2079	100	8		Vagina								
2080	10	11		Vagina								
2081	11	8		Vagina								
2084	11			Vagina		T	T					
2085	14	1		Vagina		T	T					
2086	116			Vagina			1	T				T
2087	141	8		Vagina		T			T			
2088	146	8		Vagina			1.0	T				
2089	10			Vagina	T							
2090	110	8		Vagina		T						
2091	114	8		Vagina								
2092	100	11		Vagina	T							
2093	106	11		Vagina		1.0						
Average vaginal						1.1						

amount of absorption varied with different individuals and probably depended to some degree upon both the retention of the powder and the availability of moisture for its solution. Blood concentration after rectal administration averaged twice as high as after vaginal. The drug persisted in the blood from 1 to 6 days, more than half being negative on the 3d day.

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EDITORIALS

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GASTRIC AND DUODENAL ULCER AMONG NAVAL PERSONNEL

THE seriousness of the ulcer problem is evidenced by the unexpected frequency of peptic ulcers in the civil population (especially among young men) as revealed by physical examinations incident to the war. Several authors, furthermore, have found that 90 per cent of the soldiers with peptic ulcer in the Army of the United States had symptoms of ulcer prior to entering the service. The problem from the naval standpoint does not seem to be with young recruits who have ulcers that existed prior to enlistment. When symptoms of ulcer prevent such patients from carrying on the duties of their rank or grade, they are discharged from the service because medical treatment has been of only temporary benefit in most cases and yet the patients do not have sufficient trouble to

The opinions and assertions contained herein are the private ones of the author and are not to be considered as official or reflecting the views of the Navy Department or Naval Service at large.
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Ann. Surg. 1943, 118: 489-493

warrant surgical procedures. However, when an ulcer develops after a man has entered on naval duty or, having so developed and subsided, becomes reactivated in the course of naval duty, it is important to treat the patient so that he can return to a trial period of duty (even if limited) whenever possible. This is particularly true if he is an officer or a specialist who has become a real asset to the service.

In recent reports on 1,352 patients with proved peptic ulcer, from thirteen United States Naval Hospitals^{1,2}, it is recorded that 92 per cent were treated medically and 8 per cent surgically. Half of those treated medically were returned to duty—some only to have the site of the ulcer break down later, necessitating discharge from service. Of those treated medically who were discharged from the service, 25 per cent had been hospitalized repeatedly because of their ulcers. Of those treated surgically, 71 per cent were returned to duty.

In these reports Walters and Butt presented one small series of naval patients treated by partial (subtotal) gastrectomy, 85 per cent of whom were returned to full duty. Although their series of patients was not large enough to justify definite conclusions, the authors expressed the belief that until a "much larger series of naval patients is operated on and observed subsequently as regards their reaction to naval duty," radical surgical treatment of certain naval patients with chronic, recurrent gastric or duodenal ulcers is justified. The earlier a decision can be made as to the necessity (if it exists) for surgery, the earlier the operation is done and the patient returned to duty, the better the results will be, for prolonged hospitalization is not conducive to a desire to return to combat duty.

WALTMAN WALTERS

AMERICAN COLLEGE OF SURGEONS

1944 CLINICAL CONGRESS TO BE HELD IN CHICAGO

THE thirty-second Clinical Congress of the American College of Surgeons will be held in Chicago October 23-27 with headquarters at the Stevens Hotel. Dr. W. E. Gallie of Toronto, president, and Dr. Irvin Abell, of Louisville, president-elect, will preside. The keynote of the Congress will be surgery in relation to the war.

Chicago was selected as the meeting place for the 1944 Clinical Congress because of its central location, thereby minimizing the distance traveled by those who will attend, which action is in accord with suggestions of the Office of Defense

Transportation that such meetings might be held despite current travel restrictions.

The many new developments in surgery in military as well as in civilian practice, that should be brought to the attention of the fellows, the desirability of holding a meeting of the fellows for the transaction of business, and the need for a convocation at which there might be received into fellowship the 1944 initiates as well as those upon whom fellowships were conferred in 1943 and 1944 were considered as sound reasons for holding a Clinical Congress this year. Programs for the Congress will appear in later issues.

REVISED SCHEDULE OF 1944 WAR SESSIONS

IN the February issue of this journal, page 221, the American College of Surgeons announced plans for a series of War Sessions to be held in various cities distributed throughout the United States and Canada. A revised schedule for these sessions follows:

Date	City	States and Provinces	Headquarters Hotel
Thursday March	Minneapolis	Minnesota, North Dakota, South Dakota	Nicolet
Saturday March 4	Des Moines	Iowa, Eastern Nebraska, Missouri	Fort Des Moines Stevens
Monday, March 6	Chicago	Illinois, Wisconsin	
Wednesday March 8	Cincinnati	Ohio, Kentucky, Indiana, West Virginia, Tennessee	Netherland Plaza
Friday March	Detroit	Michigan	Statler
Monday, March 13	Rochester	New York State	Seneca
Wednesday March 15	Toronto	Ontario	Royal York
Friday March 17	Montreal	Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland	Mount Royal
Monday March 20	Springfield	Massachusetts, Maine, New Hampshire, Vermont, Rhode Island, Connecticut	Kinsball
Wednesday March	Philadelphia	Pennsylvania, New Jersey, Delaware	Bellevue-Stratford
Friday March 24	Baltimore	Maryland, District of Columbia, Virginia, North Carolina	Lord Baltimore
Monday March 27	Jacksonville	Florida, Georgia, Alabama, South Carolina	George Washington
Friday March 31	San Antonio	Texas, Louisiana, Mississippi, New Mexico, Mexico	Garner Mayo
Tuesday April 4	Toledo	Oklahoma, Kansas, Arkansas, Colorado, Wyoming, Western Nebraska	Shirley Savoy Club
Tuesday, April	Salt Lake City	Utah, Southern Idaho	
Friday April	Spokane	Washington, Northern Idaho, Oregon, Montana	Davenport Vancouver
Tuesday April 8	Vancouver	British Columbia, Alberta	Mark Hopkins
Monday April 24	San Francisco	Northern California, Nevada	
Thursday April 27	Los Angeles	Southern California, Arizona	Alhambra

SURGERY

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THE TREATMENT OF BURN SHOCK WITH CONTINUOUS HYPODERMOCLYSIS OF PHYSIOLOGICAL SALINE SOLUTION INTO THE BURNED AREA

An Experimental Study

J. K. BERMAN, M.D., F.A.C.S., IOWELL PETERSON, M.D., and JOHN BUTLER, M.D.
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THE body reacts in a similar manner to trauma of all kinds. Therefore this article may properly be said to deal with a physiological method of combatting extensive external traumatic lesions, a method which may be applied in the treatment of crushing, contused, and chemical injuries as well as of burns.

CAUSES OF BURN SHOCK AND TOXEMIA

The causes of burn shock have received extensive investigation and although not fully understood the sequence of events seems to be as follows. As a result of the injury there is increased permeability of the capillary endothelium permitting the escape of plasma into the burned area (2). This leads to hemoconcentration which in turn causes a stagnant anoxemia to occur (Fig. 1). Interstitial fluid is drawn into the blood stream and is in turn lost into the burned area. As anoxemia increases, tissue cells are damaged, especially in the brain, heart, and blood vessels. Capillaries begin to lose fluid in many areas. In the ex-

perimental animal this is particularly noticeable in the lungs.

The rôle of hypothetical toxins in this process has not been determined. However, our observations compel us to recognize the possibility of the assimilation of abnormal metabolic products. Colloids and crystalloids are absorbed very early after a burn and this absorption is continued throughout its acute phase.

Many patients die from burn shock within 36 to 48 hours. If they survive this period death is thought to be due to burn toxemia. It is probably caused by a combination of such factors as dehydration, hemoconcentration, anoxemia, infection, and absorption of toxins, resulting in damage to the liver, kidneys, adrenals, lungs, and brain. Such patients usually have high fever, anuria, and pulmonary edema.

PRESENT TREATMENT OF BURNS

We have previously stated that the treatment of burn shock is based upon two important factors. First, every effort should be made to prevent the loss of plasma and electro-

From the Department of Surgery, Indiana University School of Medicine, aided by a grant from the Lilly Research Fund.

lytes. For this we urged firm pressure bandages when the burn involved the extremities (1) We found that this was not practical for the torso or face. Second the lost plasma must be replaced (2) Koch advocates that the burned area be cleansed with soap and water under aseptic conditions, blisters should be opened and a sterile pressure bandage should be applied. The use of the sulfonamides internally and ample oxygen by inhalation have also contributed to the reduced mortality from burns.

It is evident that any treatment of extensive burns must take cognizance of the following important integrants: (1) curtailment of the loss of plasma at the site of the burn no matter how extensive this may be (2) restoration of lost plasma and electrolytes (3) facilitation of dilution and excretion of toxins (4) control of body temperature. If these primary disturbances can be modified second ary effects such as hemoconcentration, anoxemia, hypochloremia, hepatic and renal insufficiency may be averted to a great extent.

PURPOSE OF EXPERIMENTS AND METHODS EMPLOYED

Our chief purpose was to lessen the loss of plasma and electrolytes and to facilitate their reabsorption. In an attempt to accomplish this we introduced physiological saline solution subcutaneously at a pressure exceeding capillary hydrostatic pressure, namely 40 millimeters of mercury.

Healthy dogs were anesthetized with sodium amytal intravenously—40 milligrams per kilogram of body weight. The animals were weighed, the hair was clipped from the forelegs down blood was drawn for hematocrit, hemoglobin, serum chloride and serum protein, uric acid, creatinine and nonprotein nitrogen determinations. Body temperature, blood pressure, pulse, and respiratory rates were noted.

The animals were then dipped into a large tub of boiling water—99 degrees C—up to the forelegs for 20 to 40 seconds. Thirty two seconds was found to produce a uniformly severe burn. A catheter was anchored in the urinary bladder. The carotid artery was cannulated, flushed with citrate solution, attached to a manometer and recorded.

One cubic centimeter of phenolphthalein solution was injected subcutaneously on one side of the lower thoracic wall and 1 cubic centimeter of India ink was introduced subcutaneously on the other side. At the same time 0.85 per cent saline solution was given by hypodermoclysis. The solution was placed in an open flask and connected with three tubes. One of these was attached to a mercury manometer so that the pressure could be maintained at 40 millimeters of mercury; the other two were equipped with hypodermic needles and were variously inserted in the thoracic, abdominal and thigh regions. In this manner amounts up to 12 per cent of the body weight were given.

Some animals received the salt solution without manometric guidance. That is, the solution was injected until the tissues were distended. The needles were allowed to remain in place and the tubes were clamped when the skin seemed tense. As absorption proceeded more solution was injected. In the dog the skin is loosely attached due to the well developed panniculus carnosus (platysma in man). Fluid introduced anywhere subcutaneously permits diffusion throughout the body. However, absorption is more rapid in the thoracic area. Results were the same in both groups of animals.

The urine was collected and tested for phenolphthalein content from time to time. Also at intervals blood was drawn for studies previously enumerated. It required extreme care to prevent hemolysis of the samples.

Each group of experiments was controlled by a burned untreated animal. Autopsies were done at the conclusion of each experiment. Microsections were made from the skin and subcutaneous tissue, lymph nodes, lungs, spleen, liver, etc.

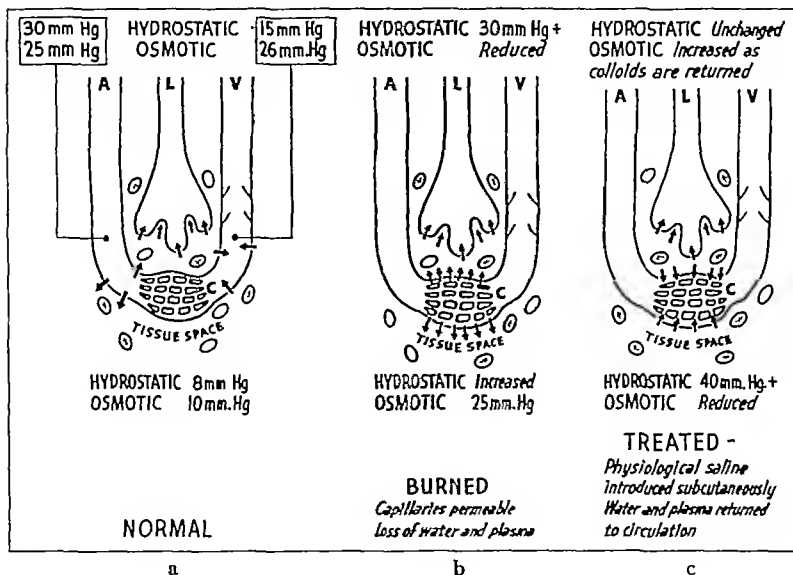


Fig 1 Mechanisms involved in the interchange of body fluids a, Normal, Starling's hypothesis assumes that blood in the capillaries is under two forces a hydrostatic pressure which tends to force fluid outward and an osmotic pressure which tends to attract fluid into the capillary. These are balanced somewhat by similar pressures in the surrounding tissues. The effective hydrostatic pressure is greater on the arterial side of the capillary, A, and therefore there will be a flow of crystalloids and solutes outward into the tissue spaces. On the venous side, V, the effective osmotic pressure is greater and fluid is attracted into the capillary. Colloids are returned to the blood stream by the lymphatics, L, which behave as a semipermeable membrane. b, Burned, the capillary wall plays an important rôle in this mechanism because it is normally impermeable to colloids which are chiefly proteins (albumin, globulin, fibrinogen, especially the former) but it is permeable to crystalloids. Anything, therefore, injuring capillary endothelium would immediately disarrange the normal interplay of these forces. c, Treated, the hydrostatic pressure in the tissue spaces is increased and the osmotic pressure is decreased. The loss of crystalloids and colloids is minimized, and their absorption into the capillaries and lymphatics is facilitated. (Redrawn from Berman's *Synopsis of the Principles of Surgery* C V Mosby Co, 1940)

average survival time for the controls was 9 hours and 24 minutes, for treated animals 14 hours and 30 minutes—an average of about 35 per cent longer.

General condition Treated animals remained in better condition and were more stable than the controls. This conclusion is based upon the regularity of respiration, heart rate, blood pressure, and temperature as depicted in the graphs and as discussed in subsequent paragraphs. Salivation occurred in all animals immediately after the burn. Soon the mucous membrane of the mouth and tongue was dry in the controls but remained moist in the treated dogs.

Pulmonary edema A constant finding was the presence of pulmonary edema in all con-

trol animals. This could be easily detected by the loud râles which were audible without the use of the stethoscope. It becomes apparent about 1 hour after the burn and becomes progressively worse. In 1 control animal a tracheotomy was done and large amounts of thick ropy fluid were aspirated. In the treated dog tracheotomy permitted the aspiration of only normal amounts of secretion. Autopsy studies confirmed the presence of edema.

The mechanisms effective in the cause of pulmonary transudates and exudates in the lung have been recently described by Drinker. The former term is used to imply the movement of fluids through normal capillary endothelium, the latter through more permeable or abnormal capillary walls. Since the normal



Fig. 2. Postmortem photograph of subcutaneous area in which cubic centimeter of India ink, as injected *a*, above, was treated with hypodermoclysis of physiological saline *b*, Control.

osmotic pressure prevails in pulmonary capillaries and since the hydrostatic pressure is extremely low (about 10 mm. of mercury) and, lastly, since the intrathoracic pressure is slightly negative (-5 to -10 mm. of mercury) the flow of solutes is entirely into the lumen of the capillary and therefore the lung is dry. Furthermore as in other tissues, colloid particles are returned by the lymphatics and in the lung these are very amply present. Therefore large quantities of fluid may be lost into the lung either as transudates or exudates or fluid may enter from some external source, but it is usually quickly returned to the blood stream through the blood capillaries or through the lymphatics.

The cause of pulmonary edema in our control dogs may have been due to the early loss of water producing dehydration and hemoconcentration. These conditions in turn lead to stagnant anoxemia causing hyperpnea. In addition the high fever probably caused more fluid to reach the lungs for evaporation so that the temperature would be reduced. The pul-

monary capillaries became more permeable due to dilation and anoxemia. These factors together with the increased rate and amplitude of respiration caused more fluid to leave the capillaries at first by transudation and later by exudation.

Absorption of colloids and crystalloids from the burned area. We were interested in knowing whether or not the injected subcutaneous saline solution would be absorbed. Also whether colloids lost from the permeable capillaries would be returned to the blood stream. To prove this we injected phenolsulfonphthalein solution 1 cubic centimeter on one side of the burned area and 1 cubic centimeter of India ink on the other at the same time that the saline solution was introduced. The latter varied in amounts from 800 to 2400 cubic centimeters. The average was 1600 cubic centimeters or 2 per cent of the body weight. Injection of fluid anywhere under the skin quickly diffused over the entire body within

4 hour. The good effect of this treatment were not so apparent when the solution was injected 2 hours or more after the burn as evidenced by anuria in some of these animals. Best results were obtained when the treatment was used immediately.

In the treated animals, phenolsulfonphthalein was detected in the alkalized urine within an average of 21 minutes after its injection. The controls had no urinary output but aspiration of a few drops of urine in the urinary bladder of some controls at postmortem did reveal phenolsulfonphthalein in the urine. Examination of the site of injection showed the solution to be present as a large bleb in controls; it was almost completely absorbed in the treated animals.

Fluid injected in the thoracic wall was much more quickly absorbed than in the abdominal area or the subcutaneous tissue over the extremities. In some animals the absorption was complete within 1 hour.

Injection of India ink revealed comparable findings. In the treated animals it was found in the anatomical lymph nodes, the lungs, liver and spleen. In the controls small amounts were detected sporadically in these organs. However most of it remained as a large bleb at the site of injection (Fig. 2). We concluded

from these and subsequent findings that subcutaneous isotonic salt solution at 40 millimeters of mercury pressure not only decreased the outward flow of plasma protein, as revealed by the discussions which follow, but in addition facilitated the absorption of crystalloids and colloids as well, the latter by the lymphatics, after the injured tissues' increased demand for salt had been satisfied

Body temperature There was a uniform rise in temperature of about 1 degree F in the control immediately after the burn, which remained constant for about 3 hours. Then a rapid rise occurred which became progressively higher (Fig 3). The animals died with temperatures averaging 105 degrees F. The treated animals behaved differently. Body temperatures began to fall within 1 to 2 hours after the burn, reaching 97 degrees after 5 hours and remaining at this level for about 2 hours. After this the temperatures remained normal.

The initial rise in the controls was probably not due to the absorption of hypothetical toxins, or dehydration because the time interval was too short. We believed that it was due to a condition allied to heat stroke which was controlled in the treated animals. It was our opinion that this method of treatment could be used in heat stroke and shock. The terminal hyperpyrexia in controls was probably caused by a combination of factors such as dehydration, anuria, pulmonary edema, and absorption of toxins. These were corrected in great measure by the hypodermoclysis in the treated animals which might also have been the means of dilution and elimination of toxins.

Pulse rate The pulse rate in the treated animals was more uniform and in general slower than in the controls. Dogs with pulse rates of 140 to 150 immediately after the burn, fell to 100 within 2 hours after treatment, then gradually increased. Controls showed a rise in pulse rate which was sustained for about 3 hours. After this the pulse became very weak by the rate decreased rapidly. This was thought to be due to incomplete cardiac contractions (Fig 3).

Respiration Untreated animals had irregular deep respiration with varying periods of apnea. During the first 6 hours this irregularity ranged between 10 and 28 per minute.

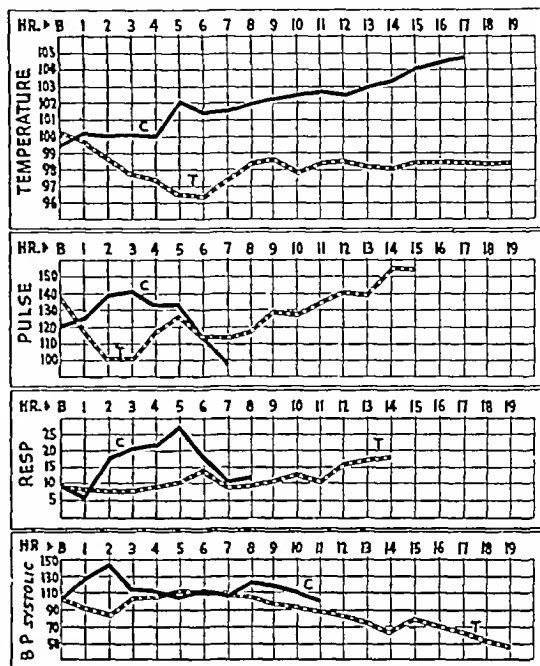


Fig 3 Composite graphs of body temperature, pulse, respiration, and blood pressure. Hourly readings were averaged for all treated animals, T, and controls, C.

After this period respirations dropped to an average of 9, but were not shallow. This rate increased until death. Treated animals also had varying rates and amplitudes which were more or less constant, increasing progressively until the death of the animals. Averages were difficult to obtain because of minute variations. However, the composite chart reveals in a general way the behavior of the treated and untreated dogs (Fig 3).

Blood pressure Control dogs showed a rise in blood pressure immediately after the burn. Within 2 hours the average systolic pressure had increased 40 millimeters of mercury. This remained only 20 to 30 minutes then rapidly declined. Treated animals had a slight fall in pressure immediately after treatment. Within 2 hours after the burn it had fallen on an average of 20 millimeters of mercury. This level remained for only 20 to 30 minutes then regained its previous level which was sustained for 4 to 6 hours. After this there was a gradual fall (Fig 3). The findings in our controls agree with those of Olson and Necheles,

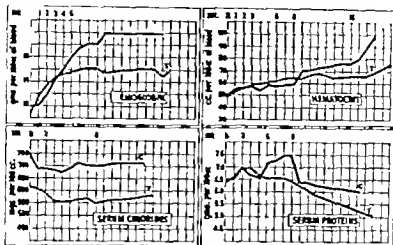


Fig. 4. Composite graphs of hemoglobin, hematocrit, serum chloride, and serum protein. Blood samples were drawn at various intervals throughout the experiment. Figures for comparable time intervals are then averaged. C Control T treated dogs.

who thought the pressor effects due to stimulation of the posterior pituitary.

The behavior of the respiration, pulse, blood pressure and temperature is difficult to correlate especially in the controls which behaved in an erratic manner. However in treated animals the entire picture was one of stabilization near normal levels.

Uinary output. Immediately after the burn all dogs passed 8 to 10 cubic centimeters of urine. Anuria was present in practically all of the controls as the experiment progressed. The average amount of urine put out by the controls was 17.3 cubic centimeters and all of this was early in the experiment. Treated animals continued to excrete urine throughout the experiment if the salt solution was given immediately after the burn. The average output was 66 cubic centimeters. If 1 to 2 hours was allowed to elapse before treatment only a few drops of urine were excreted. One group of treated animals burned for 40 seconds died within 2 hours. Only a few drops of bloody urine were excreted and the kidney pelvis were filled with blood. Changes in the kidneys take place rapidly and treatment to be effective must be instituted early. Corcoran and co-workers have recently explained some of the kidney behavior by a vasoconstriction of the efferent glomerulus arteriole.

Examination of the urine in controls was impossible except early in the experiment. At this time there was a faint trace of phenol sulfonphthalein, some albumin, some blood. Treated animals began to excrete phenol sulfonphthalein within 10 minutes after its injection. Sugar was negative, albumin averaged 0.864 grams per cent, there was no bilirubin, some oxidized urobilinogen and on microscopic examination some red blood cells were found.

Body weight. At the conclusion of our experiments before postmortem examinations were done the animals were weighed. Those treated with physiological saline solution gained on an average of 1.33 kilograms or 2.93 pounds. This is slightly less than the average amount of fluid injected. The difference was no doubt due to fluid loss by the lungs and kidneys. Control animals uniformly lost weight. The average amount was 0.33 kilogram which was due to loss of fluid chiefly by the lungs for this is the dominant method of evaporation in the dog.

Blood studies. (a) *Hematocrit.* All animals showed a rise in hematocrit readings. This began immediately after the burn and continued throughout the experiment. Control showed a much greater average rise (up to 60%) than do the treated animals which rose to 76 per cent (Fig. 4).

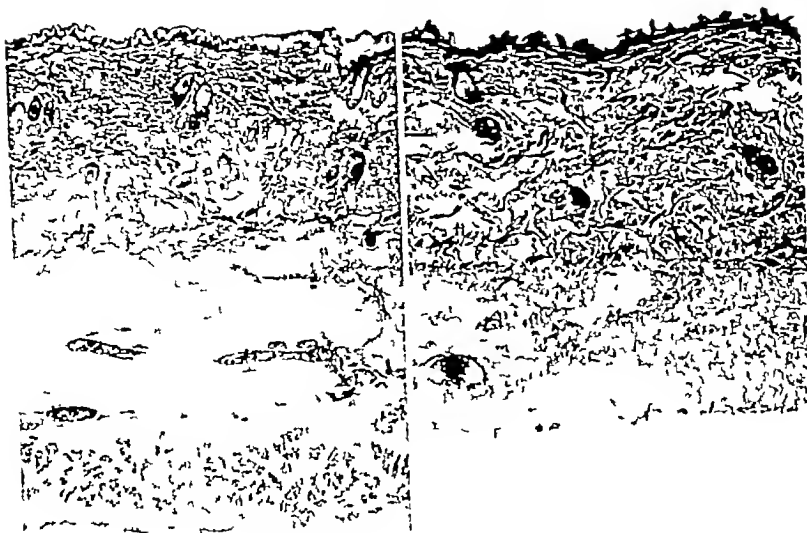


Fig 5 Photomicrographs of skin and subcutaneous tissue showing second and third degree burns. Note the space caused by physiological saline in the subcutaneous area of the treated animal a, left, Treated dog, b, control

(b) The *hemoglobin* determinations paralleled the hematocrit findings and were even more striking. Controls showed an average rise from 12 to 18 grams. This elevation occurred abruptly 2 hours after the burn. Treated dogs behaved in a similar manner, but the rise was up to 15 grams and remained at this level throughout the experiment (Fig 4).

(c) *Serum protein* There is an initial slight rise in serum protein in all animals. Four hours after the burn control animals show a rapid rise from 6.6 to 7.5 grams which is sustained for about 3 hours, then there is an abrupt fall which continues throughout the experiment. Treated animals show a slight but progressive fall beginning 3 hours after the burn (Fig 4). This behavior we believe is due to the early loss of water which in the control continues for about 8 hours then there is a shift of fluids from the tissues to the blood stream. Also capillaries begin to lose protein in large amounts at this time. Treated animals have their water restored from the start and, except for the 2 hour lag at the beginning of the experiment, protein is gradually lost although restoration is going on. Of course the protein level will have become lower as a result of hemodilution.

(d) *Serum chloride* Immediately after a burn, controls show a quick fall within the first hour amounting to an average of 75 to 100 milligrams. A slight rise occurs at 6 hours for a short time, then there is a fall with no variation. Treated animals show only a slight fall which is progressive for about 3 hours then there is a slight but constant rise. By referring to Figure 4 it will be noted that the early fall in chlorides corresponds to the rise in serum protein. In the controls the secondary rise in protein is accompanied by a slight rise in chlorides. Since volumetric studies were not made total changes cannot be recorded. However, these figures seem to indicate first a loss of water and electrolytes, then migration of crystalloids into the blood stream for osmotic reasons, then a loss of plasma with continued migration of water and protein from tissue spaces into the blood. Treated animals do not show this large loss of electrolytes or proteins, although the trends are the same.

(e) *Azotemia* All animals showed a rise in nonprotein nitrogen, uric acid, and creatinine levels. In most instances there was a more rapid and greater rise in the controls than in the treated animals. Nonprotein nitrogen in controls rose from an average of 25 to 74 milli-

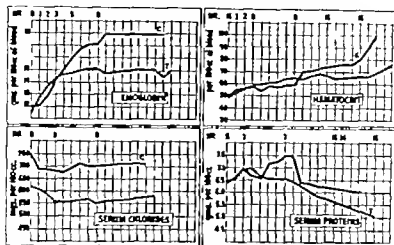


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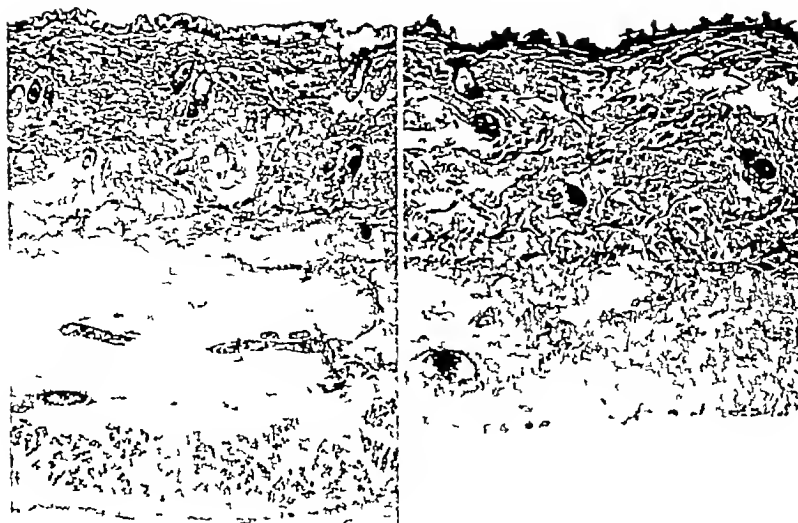


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Fig. 6. Photomicrographs of the lungs in a, left, treated, and b, control, dogs. There are congestion and pulmonary edema in the latter. India ink is abundantly scattered throughout the lungs of the treated animal. Note the thickened alveolar walls. On high power this is seen to be due to great leukorrhea. There is some bloody exudate in the alveoli and bronchioles.

grams treated animals from 30 to 50 milligrams. Uric acid in controls increased from 3 to 6.2 milligrams in treated dogs from 3 to 4 milligrams. Creatinine in controls averaged .26 milligrams at the beginning of the experiment and 1.90 at its end. Treated dogs showed a rise from 1.20 to 1.76 milligrams.

Splenectomized dogs. Control and treated splenectomized dogs behaved very much as the other animals with one outstanding exception hemoglobin and hematocrit readings were much lower. This observation together with the contracted spleens found at post mortem in other animals, would lend support to the belief that at least some hemoconcentration after a burn is due to the large volume of blood released from the splenic reservoir.

Postmortem studies. It was our purpose to find the extent of India ink absorption and to record any notable changes encountered. Detailed microscopic morphological studies are not included in this study. The animals were allowed to die of their burns. The skin showed second and third degree burns (Fig. 5). Treated animals showed a separation of the skin from the fascia due to the injected fluid. Lymph nodes in control and treated dogs contained India ink much more was found in the latter.

The pleural cavities did not contain free fluid. The lungs of control dogs were wet and showed pulmonary edema. Treated dogs did not exhibit this. India ink particles were found in both but again there was much more in treated animals (Fig. 6). There was no free fluid in the abdominal cavity. Intestines were congested in controls but were pale in treated dogs. One control dog was found to have a duodenal (Curling's) ulcer. The spleens were contracted in all animals. Spleens in controls had less India ink particles than in treated dogs. Kidneys were hyperemic and congested in controls. Some tubules were filled with blood. Changes were not constant in either group. The livers of controls showed areas of focal necrosis some cloudy swelling and a small amount of India ink. Treated dogs had much more India ink and more nearly normal livers. Adrenals showed no significant differences.

We concluded from our findings that there was a widespread dissemination of India ink in treated animals which was not as apparent in controls. This would further prove that lost protein is reabsorbed and sent to all of the vital organs of the body. Pathological changes were found in both groups but were less apparent in treated dogs.

RECAPITULATION

Our studies lead us to believe that there is first a loss of water then plasma into the burned area. This continues until the tissue space pressure equals the hydrostatic pressure within the capillaries. Then reabsorption begins but in a reverse manner. That is, colloids are returned first by the lymphatics which behave as a semipermeable membrane. Then crystalloids are absorbed by the capillaries.

The loss of plasma occurs earlier in animals more severely burned, therefore, early treatment is imperative.

Treatment by hypodermoclysis of isotonic salt solution seems to decrease the amount of water and plasma lost and it facilitates the absorption of both. Prinzmetal and associates have observed that the intraperitoneal administration of a 0.9 per cent solution of sodium chloride in large amounts (5 to 10% of the body weight) to mice and rats after scalding significantly decreases mortality. Rosenthal observed this to be due to the sodium ion and found that isotonic solution of sodium salt given orally was more effective than the same solution given intravenously. These findings lend strong support to our observations. Perhaps water given by mouth to burned patients would be retained in the blood stream if sufficient sodium chloride was administered at the same time.

Human skin is not as loosely attached to the subcutaneous tissue as is that of the dog and therefore multiple injections would be necessary but much less solution would be needed to produce an intercellular hydrostatic pressure above that of effective capillary pressure. This method has not been employed in the human. However, its feasibility is apparent and could be used in addition to intravenous plasma and other methods of treatment. Certainly it would decrease the amount of plasma which has recently been found to be

necessary in treating extensive burns. It is indeed an autotransfusion of lost colloids and crystalloids, and in addition a method for supplying quickly the great demand for salt by injured tissues.

CONCLUSIONS

Isotonic sodium chloride solution injected hypodermically into the burned area in experimental animals curtails the loss of plasma and electrolytes, makes possible the dilution and excretion of hypothetical toxins, controls body temperature, prevents pulmonary edema and anuria. As a result of these effects survival time is considerably increased in the treated animals.

Since submitting this article for publication Fox (14) has described the treatment of burned patients with the oral administration of sodium lactate. By using radioactive sodium he has demonstrated an enormous deposit of this element in the traumatized tissues of experimental animals.

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THE LOCAL SKIN LESION IN EXPERIMENTAL BURNS AND ITS RELATION TO SYSTEMIC MANIFESTATIONS

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THE necrosis of the skin in clinical burns is generally classified only according to its depth without recognition that necrosis may assume different forms. Yet it has long been known that a dry, hard necrosis of the skin is apt to be produced by flame (2). Early in our experimental studies it seemed clear that the damage to the skin varied not so much in depth as in intensity, one of the first observations being the existence of either a dry necrosis or a wet necrosis of the skin, dependent upon different types of burn stimuli. We had previously noted the same two types of necrosis in many clinical burns. For these reasons, we decided to study more carefully the nature of the burn lesion produced by varying thermal injuries.

METHODS

Varying types of thermal stimuli occur in actual warfare or in civilian accidents. In most of them the individual is either burned by hot water or oil which comes in direct contact with the skin or by the actual flame, usually when his clothes catch fire. To this must be added a relatively new type of burn called the flash burn which is a very intense but momentary thermal stimulus producing however a superficial injury usually involving necrosis of tissue.

In the setting up of methods for experimental burns a number of procedures are available which may be listed as follows:

The actual flame. This method is usually carried out with a Bunsen flame. The degree of injury is hard to control, and as we observed in our earlier experiments the lesion produced is quite variable. Because this procedure, moreover, scarcely imitates the conditions observed clinically we soon discarded this technique. On the other hand, a more accurate

method of studying the effect of flame under conditions approximating that observed clinically is achieved by igniting a measured amount of gasoline poured over the skin. Thus the degree and duration of the flame can be accurately measured. This was one of the techniques we used in the present study.

The dipping technique. This method is capable of accurate control and requires simply the immersion of a measured portion of the body surface into a liquid at any desired temperature for any length of time. Moreover, it imitates rather well what happens clinically whenever a person is burned by hot water or oil, and is the one we used in our original experiments as already described (1). It should be mentioned however that very short lasting immersion probably approaches more closely the conditions observed clinically inasmuch as it is quite unlikely that in human burns the hot water or oil will remain in contact with the skin more than a few seconds.

The application of a heated object. This method permits the study of small isolated areas but has an important disadvantage in that pressure is applied as well as heat, a fact which increases the degree of the injury. Moreover, such a burn stimulus is seen clinically only over relatively small areas which present no great problem in treatment. We therefore discarded this particular method of studying thermal injury.

Radiant heat. The actual cautery when applied to the skin, inevitably involves a certain amount of pressure which, as mentioned, introduces an additional and uncontrollable factor. However, if the tip of the cautery is held a few millimeters from the surface of the skin, one can produce a burn by radiation uninfluenced by the effect of pressure and which can be controlled fairly well, although not as accurately as the immersion or the flame technique described. Another way of applying radiant heat is the use of magnifying

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lenses to focus a spot of concentrated light on the skin for varying intervals of time

EXPERIMENTAL FINDINGS

In all about 25 animals were used in this study. All observations were made on deeply anesthetized dogs whose hair had been removed previously.

By using the technique described, the types of skin lesions observed can easily be classified into three groups as follows

1 *Inflammatory reaction with edema but no necrosis* As mentioned in our previous communication (1), immersion of the deeply anesthetized dog for 5 seconds in water at 80 degrees C is followed by an inflammatory reaction including edema without necrosis or infection. If the animal survives, this edema subsides after 24 hours or more and leaves little or no permanent effects in the skin. Inflammatory edema may also be produced with higher temperatures provided the period of exposure is momentary. For example, heated mineral oil up to 180 degrees C dropped on the skin produces an edema which subsides. If a large volume of such a hot liquid is poured upon the skin over a period of 1 or more seconds, the area covered by the oil will be similarly edematous, although in the center necrosis will occur. With radiant heat as produced, for example, by an actual cautery which is held a few millimeters from the skin but not in contact with it, edema will result if the exposure is momentary, but any exposure beyond 1 or 2 seconds will result in definite necrosis. The actual flame also produces edema provided it is of short duration, e.g., if a drop of gasoline is placed upon the skin and set fire, the resulting lesion will consist of edema only. It is only when the flame burns for more than 1 or 2 seconds that actual necrosis occurs.

2 *Wet necrosis of the skin* On immersion of deeply anesthetized dogs in water at 100 degrees C for periods beyond 2 and up to 10 or 15 seconds, a necrosis of the skin will be produced which manifests itself within a day or two as a swollen, moist, necrotic area which becomes infected rapidly. This lesion is particularly prone to occur on the inner surface of the thighs rather than the outer surface,

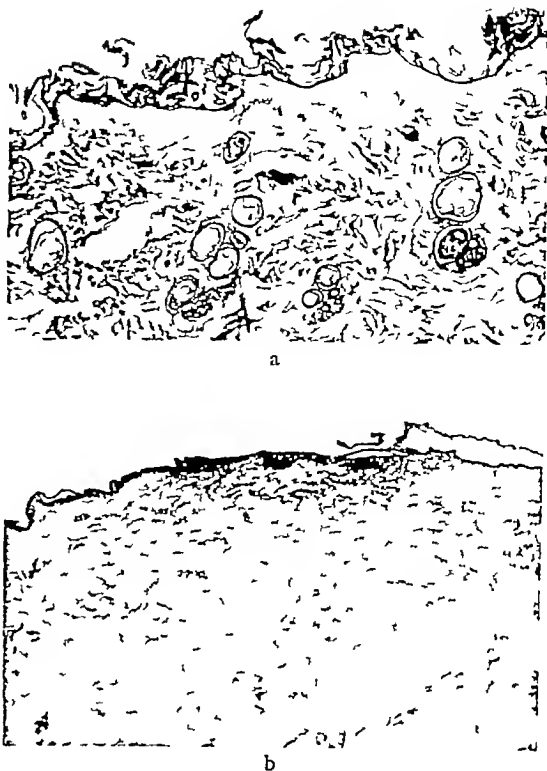


Fig 1 Photomicrographs of skin subjected to thermal injury by immersion in water at 100 degrees. Specimens removed at the end of 24 hours, a, from the inside of the left leg which had been exposed to a thermal stimulus for 20 seconds. Note the intact epithelial layer and the swelling of the dermis with little evidence of inflammation. In b, removed from the inside of the right leg, the exposure was 20 seconds. Note the disappearance of the epithelial layer, the evidence of infection as shown by inflammatory cells and the extensive edema. $\times 34$

although there is considerable variation from animal to animal. Of special interest was the fact that hemorrhage of the adrenal was observed when this type of lesion was produced and if survival for 24 hours or more occurred, a finding which was never observed when edema alone was produced. Microscopic study of the skin lesions showed disappearance of the epithelium, edema, infiltration of leucocytes and other signs associated with infection (Figs 1b, 2b, and 3b).

3 *Dry necrosis of the skin* In deeply anesthetized dogs immersed in water at 100 degrees C for 20 seconds or more, a necrosis of the skin occurred but it was of the dry type



Fig. Photomicrographs of similar experiment, 1 that described in Figure except that the specimens were removed 1-48 hours. In section a, note the coagulation of the dermis and the intact epidermis. In section b, note the disappearance of the epidermis and the intense reaction with edema and infiltration of leucocytes. $\times 34$

Indeed, immediately after immersion the involved skin was hard and coagulated, unlike the skin with less severe injury which usually showed no particular gross change immediately. With the development of dry gangrene a line of demarcation formed as with wet gangrene but infection of the hard dry skin did not occur though it tended to slough quite easily a phenomenon we have observed in similar lesions clinically. Dry necrosis tended to occur more readily over the dorsum of the thigh than the inner surface which was more apt to show a moist necrosis. Microscopic section showed no alteration in the normal appearance of the epithelium, the nuclei being intact even though the tissue was examined 24 or more hours after the injury. However the fibers of the dermis were swollen

and stained deeply. No edema or inflammation was seen (Figs. 1a, 2a and 3a). Indeed, the tissue may be said to have been fixed by the heat almost as if the skin had been immersed in a fixing fluid. However a narrow zone between the normal and coagulated skin often exhibited the wet necrosis which has been described.

Which of the 3 types of lesions just described actually occurred depended upon the duration of the burn stimulus as well as upon its intensity although other factors are apparently decisive. These other factors undoubtedly deal with the ability of the skin to cool itself i.e. its ability to carry off the heat and thus avoid the effects of the thermal stimulus. This cooling influence is undoubtedly mediated largely through the blood flow although loss of heat by conduction and radiation may also play a rôle. The cooling effect of the blood flow is indicated by the following observations.

Necrosis is more apt to occur in the skin over bony prominences where pressure is more likely to develop. This pressure by interfering with blood flow undoubtedly increases the likelihood of severe injury. It is probably for the same reason that contact (pressure) methods of producing thermal burns produce a much more severe burn with a lower temperature than similar burns produced without actual contact of the source of heat.

The skin of the extremities invariably shows a greater degree of damage than the torso. For example the toes react more sensitively to the same thermal stimulus than the thigh or lower abdomen. This is most likely due to the fact that the blood supply of the leg and foot is poorer because it is more terminal and has fewer collaterals.

When one observes the burn produced by pouring heated oil (180 degrees C.) over the surface of the torso the center will become necrotic whereas the periphery will merely show edema. This difference is often seen in clinical burn the more severe lesion occurring in the center the periphery showing much less extensive damage. It seems obvious that the uninvolved blood supply at the periphery carries off the heat and thus minimizes the injury.

ANALYSIS OF OBSERVATIONS

Although the experiments herein described deal primarily with the correlation of the nature of the local lesion with the thermal stimulus, they suggest interesting inferences between the severity of the local lesion and the systemic manifestations. Thus the production of inflammatory edema alone is clearly the cause of loss of plasma leading to hemoconcentration, fall of blood volume, and the physical changes responsible for surgical shock. These systemic changes are transient, however, and unless too severe, are combated by the compensatory mechanisms of the body or corrected by plasma transfusions. On the other hand, when the thermal stimulus produces a necrosis of the skin, the *type of necrosis*, not merely its *depth*, becomes of crucial significance. Familiar to most surgeons are differences between wet and dry gangrene of the extremity in so far as the presence or absence of systemic manifestations is dependent thereon. It would seem from the experiments herein reported that a similar difference may occur in the necrosis of skin produced by a burn. True enough, infection always enters the picture and after a sufficient time has elapsed undoubtedly accounts for many of the systemic manifestations. However, many systemic effects which become apparent before infection gains a foothold may be due to the presence of wet autolyzing tissue. The fact that hemorrhage in the adrenal was not observed during the production of inflammatory edema but only with the production of wet necrosis adds further evidence to the probability of this mechanism. While further study is indicated, there is increasing recognition that the presence of such damaged tissue is an important factor in shock and that such "toxic" factors may account for certain early deaths in extensive burns adequately treated with plasma transfusions.

From the practical point of view the experiments described herein assume clinical significance because they point out that the present classification of burns is inadequate in that it fails to differentiate between wet and dry necrosis. Such a differentiation may prove important by explaining certain severe clinical manifestations not due to loss of plasma.

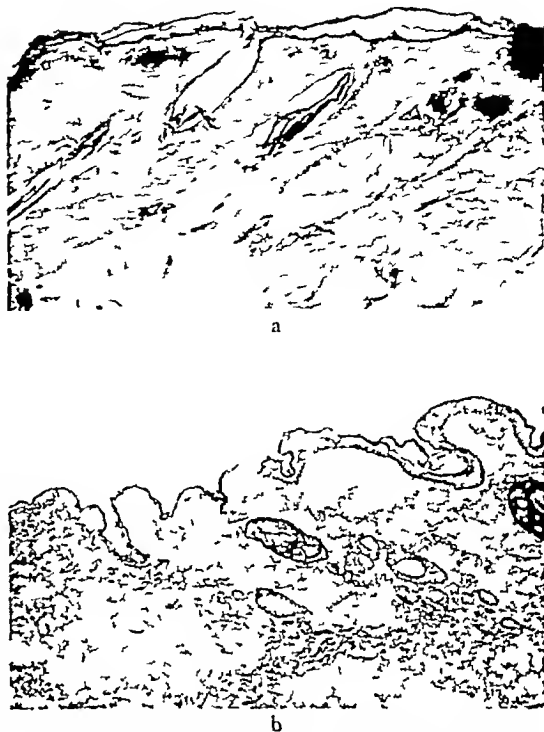


Fig 3 Photomicrographs of skin subjected to thermal injury. In section a, the skin was immersed at 100 degrees for 30 seconds. Specimen removed at 48 hours. Note the coagulation of the dermis and the intact epidermis and relative absence of inflammatory reaction. In section b, skin was immersed at 100 degrees for 10 seconds. Specimen removed at 48 hours, at the line of demarcation. Note on the left the disappearance of the epidermis and the intense inflammatory reaction. The intact epidermis of the uninjured skin is noted on the right. $\times 34$

SUMMARY

Experimental thermal injuries are described and the production of 3 types of skin damage, i.e., edema, wet necrosis, dry necrosis, with variations in the intensity and duration of the burn stimulus as well as with the cooling effect of blood flow are correlated. The importance of differentiating wet and dry necrosis in human burns is discussed and evidence is presented suggesting that the former lesion may produce "toxic" manifestations.

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LATERAL RUPTURE OF THE CERVICAL INTERVERTEBRAL DISCS

A Common Cause of Shoulder and Arm Pain

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PAIN in the arm and shoulder is a complaint almost as common as pain in the back and leg. These symptoms are too frequently called neuritis—toxic or inflammatory in origin. This misconception has been corrected with respect to back and leg pain, due primarily to a better understanding of the mechanical factors involved in weight bearing. However the various pathological lesions which commonly cause arm pain are still generally misunderstood.

The primary purpose of this report is to call attention to the rôle of the lower cervical intervertebral discs in the production of shoulder and arm pain. Also an effort will be made on the basis of neurological symptoms and signs to clarify the various painful radicular syndromes affecting the upper extremity.

The data upon which statements in this paper are based were collected from a verified cases of ruptured cervical discs and are summarized in Table I.

LITERATURE

Most published reports of cervical intervertebral disc ruptures have indicated that the lesion is most likely to be confused with neoplasms of the cervical cord. It has been generally believed that cervical herniations of the nucleus pulposus occur near the midline of the anterior wall of the neural canal and therefore cause symptoms by compressing the spinal cord. However Semmes and Murphy in a recent article describe the relatively minor symptoms produced by lateral ruptures of the cervical intervertebral discs and suggest that these cases are far more common than those in which the spinal cord is compressed. Their

lucid report promises to become a landmark in the understanding of the painful arm and shoulder.

Other observers have described the symptoms produced by bony spurs in the intervertebral foramina compressing the cervical nerve roots. Nachlas quite rightly indicated that most cases of scalenus anticus syndrome were really cases of cervical root compression at the intervertebral foramina, and he obtained relief in many of them by traction on the cervical spine. Oppenheimer and associates (12-13) after the study of 50 similar cases came to the same conclusion. Keyes and Compere called attention to these hypertrophic bony changes but indicated that the lesion was probably initiated by a damaged intervertebral disc at the site of the bony spur and that primary cervical arthritis rarely causes localized root compression.

The rôle of the scalenus anticus muscle in the production of arm and shoulder pain has been stressed by numerous authors. Unfortunately its importance has been overemphasized in some quarters, and as a result many disappointing operations have been performed and much time has been wasted in misdirected conservative treatment.

ANATOMY AND PHYSIOLOGY

The cervical spinal canal is more nearly filled with nervous tissue than either the dorsal or lumbar regions consequently an intraspinal mass causes early symptoms of cervical cord deficit. The cervical roots, unlike the dorsal and lumbar roots, emerge from the dura mater at right angles and lie immediately over the intervertebral discs. As a consequence a lateral protrusion of a cervical disc may compress the nerve root against the

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ligamentum flavum, lamina, pedicle, or facet without much damage to spinal cord (Fig 1).

The intervertebral foramina of the cervical spine have long vertical diameters with shallow anteroposterior diameters. The roots, as they pass through these foramina, are especially vulnerable to pressure from a small bony spur or a laterally placed herniation of the nucleus pulposus (Fig 2).

The points of greatest strain in the cervical spine are at the 5th and 6th interspaces. Roentgenologists have long recognized the frequency with which the intervertebral disc is narrowed at these levels. The narrowed disc may be associated with x-ray evidence of localized arthritis (Fig 3). Many patients with such x-ray findings have no symptoms referable to the neck or arms.

The cervical spinal cord is composed of 8 segments with 8 anterior roots and 7 posterior roots, the 1st cervical posterior root is usually absent. The 1st cervical motor root leaves the canal between the occiput and the atlas. The 8th cervical nerve exits at the foramen between the 7th cervical and 1st thoracic vertebrae. Therefore, a disc lesion at C-5 (between the 5th and 6th cervical vertebrae) causes direct impingement upon the 6th cervical nerve root, and one at C-6 (between the 6th and 7th cervical vertebrae) compresses the 7th cervical root. Recognition of this anatomical arrangement is important if the lesions are to be localized accurately on clinical findings.

PATHOLOGY

Cervical ruptured discs may follow severe or minor injuries to the neck, many patients, however, give no history of trauma. In analyzing the reported cases, it would appear that those cervical disc lesions which compress the spinal cord are much more frequently the result of trauma than the small laterally placed lesions which cause only arm and shoulder pain. That degenerative processes play an important rôle in the production of the lesion is indicated by the frequency with which there is roentgen evidence of localized arthritic spurs and narrowing of the intervertebral disc at the site of the lesion.

The quantity of nucleus pulposus in a cervical disc is relatively small as compared

with the lumbar region. As a consequence, even in acute cases, one is surprised to find at operation a relatively small mass compressing the nerve root or even the spinal cord. In many instances, the herniated portion of the disc is surrounded by bone. These bony prominences, known as osteophytes, may project into the intervertebral foramina.

SYMPTOMS

Pain and stiffness of the neck are usually the first symptoms. Not infrequently, after the initial bout of stiff neck, the patient will experience no further local discomfort. Symptoms may consist entirely of pain into the shoulder and down the arm into the hand. Any sudden movement of the head or neck, coughing, straining, or sneezing may intensify the pain or produce a feeling of "electrical shock" into the arm and hand.

The pain is usually made worse by maintaining a single position. Not infrequently, a patient, in order to relieve the discomfort, will get out of bed several times at night to change his position completely. The points of maximum pain are the base of the neck, the tip of the shoulder and the arm down to the elbow. Occasionally, the pain extends into the hand, but paresthesias and numbness in the hand are usually more aggravating than is the pain.

Not infrequently, the patient states that his whole hand "goes to sleep," that it has a feeling of numbness, that it feels cold to touch, and that it appears blue in color. As will be pointed out later, these vascular symptoms are part of an associated scalenus anticus muscle spasm which may completely becloud the clinical picture. Weakness of the arm and at times atrophy and fibrillation of muscles are frequently noted and may be severe.

If the lesion is a large one and compresses the cervical cord, the usual symptoms of spinal cord deficit are present. These symptoms are identical with cervical cord tumor and will not be reiterated here.

SIGNS

Sensory Strangely, many patients complain severely of recurrent numbness and tingling into the hand and forearm, and yet no sensory deficit can be demonstrated by the

TABLE 1. IMPORTANT CLINICAL AND RADIOGRAPHIC DATA FROM 12 VERIFIED CASES OF RUPTURED CERVICAL DISCS

[illegible]

usual clinical tests In the same case, if the neck and head are tilted toward the painful side and pressure is applied to the top of the head, the whole radicular pattern may be reproduced If the compression has become long and severe, sensory deficit can usually be demonstrated with ordinary tests Paresthesias can occasionally be demonstrated by gently stroking the skin in the involved dermatome The sensory patterns associated with lesions of the sixth and seventh cervical roots are illustrated in Figures 4 and 5

Motor Objective muscular weakness may be difficult to demonstrate even though the patient complains that the involved extremity is weaker than normal When muscle deficit can be demonstrated, it may have great diagnostic as well as localizing significance The biceps brachialis is supplied chiefly through the 5th and 6th cervical nerve roots whereas, the triceps brachialis is supplied chiefly through the 7th and 8th cervical nerve roots Therefore, weakness of the biceps with normal triceps function frequently occurs with lesions of the 6th cervical root (the disc between the 5th and 6th cervical vertebrae) A weak triceps and a normal biceps indicate a lesion of the 7th cervical nerve root (the disc between the 6th and 7th cervical vertebrae)

Reflex changes Lesions at C-5 disc are characteristically associated with diminution

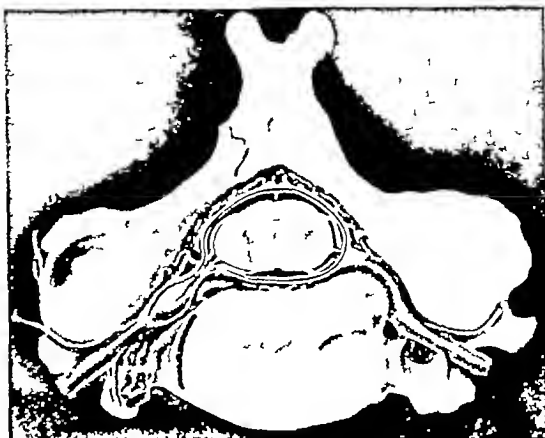


Fig 1 Diagrammatic sketch illustrating the mechanism by which a laterally placed ruptured disc may compress the nerve root without appreciable impingement upon the spinal cord

or absence of the biceps reflex, whereas, lesions at C-6 disc are associated with diminution or absence of the triceps jerk The other tendon reflexes in the upper extremity are usually not involved with lesions at these levels

Spinal tenderness at the site of the lesion is a frequent finding as in lumbar herniations of the nucleus pulposus Percussion or pressure to the painful side of the midline may reproduce the radicular pain or paresthesias—radiating percussion pain (Fig 6)

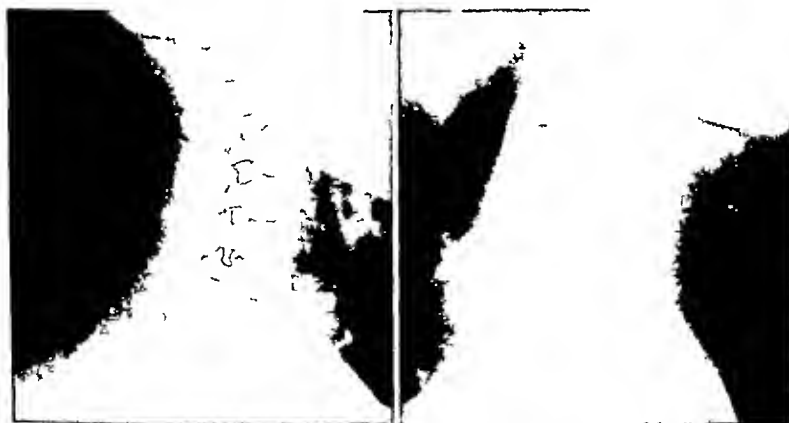


Fig 2, left. Case 1 Oblique view of cervical spine showing narrowing of intervertebral foramen at C5 Note small osteophytes on anterior margin of the foramen

Fig 3 Case 1 Lateral view of cervical spine Arrow points to narrowed disc between 5th and 6th cervical vertebrae Note chip fracture of superior surface of body of 5th cervical

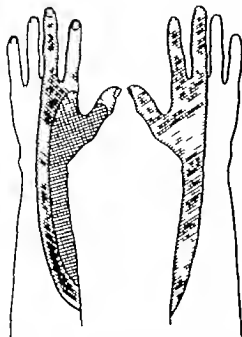


Fig. 4, left. Dorsal view of forearms and hand illustrating the approximate areas into which pain or paresthesias radiate or in which sensation is diminished when the 6th and 7th cervical roots are compressed. The cross-hatched area corresponds roughly to the 6th cervical dermatome, the lined area to the 7th cervical dermatome.

Fig. 5. Ventral view of the forearms and hand illustrating the approximate areas into which pain or paresthesias radiate or in which sensation is diminished when the 7th cervical root is compressed.

The most important diagnostic test and one that is almost pathognomonic of a cervical intraspinal lesion is the "neck compression test" (Fig. 7). Tilting the head and neck toward the painful side may be sufficient to reproduce the characteristic pain and radicular features of the lesion. Pressure on the top of the head in this position may greatly intensify the symptoms. Tilting the head away from the lesion usually gives relief.

DIFFERENTIAL DIAGNOSIS

Bony lesions of the cervical spine either neoplastic or inflammatory may compress one or more nerve roots in the foramina and cause radicular pain similar in every respect to cervical disc lesions. Neoplasms of the spinal cord, particularly those arising from the nerve roots, may give identical symptoms.

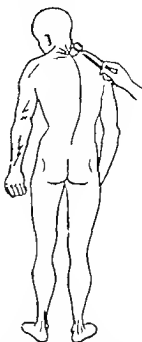


Fig. 6. Radiating pain can frequently be produced by percussing directly over the lesion. When present, the test causes pain or paresthesias to radiate into the shoulder and arm.

Scalenus anticus compression with or without cervical rib is the lesion most easily confused with ruptured cervical discs. The most important differential feature is that the nerve pain and paresthesias from scalenus anticus compression are referred to the dermatomes of the 1st thoracic and 8th cervical nerve roots (the ulnar distribution) whereas, the pain and paresthesias of cervical disc lesion are in the distribution of the 6th or 7th cervical nerves (radial or median distribution). Cervical ruptured discs below the level of the 6th interspace rarely occur; therefore, it should not be too difficult to separate the two lesions in the differential diagnosis. Furthermore the scalenus anticus syndrome characteristically has a vascular component since the subclavian artery is so easily compressed against the 1st rib in the scalenus angle.

It should not be forgotten that any lesion of the cervical spine may produce spasm of the scalenus muscle. It is not uncommon, in fact, to have the clinical features of a ruptured

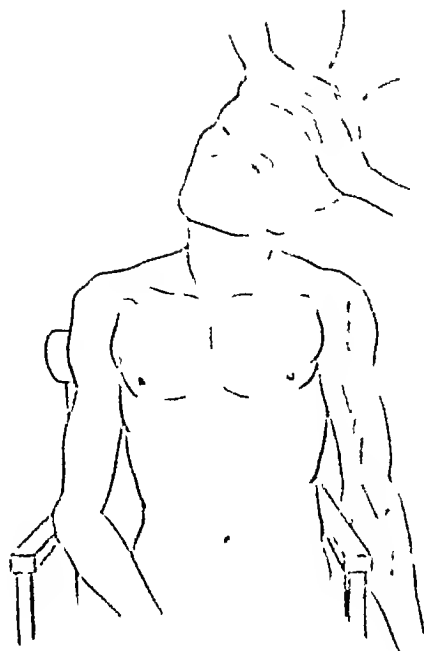


Fig. 7. Method of performing neck compression to test patients with suspected ruptured cervical discs.

cervical disc overshadowed by a superimposed scalenus syndrome (cases 2 and 11 Table I). However, if by compressing the neck toward the painful side, pain, paresthesias, and numbness into either the 6th or 7th cervical dermatome are produced, one may be sure that the symptoms are not due to scalenus compression, for these nerves cannot be involved by pressure within the scalenus angle.

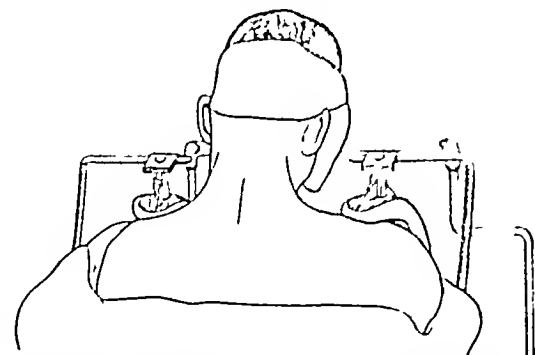


Fig. 10. Posterior view of patient in the upright position for lower cervical hemilaminectomy. Note line of operative incision.



Fig. 8, left. Case 1. Pantopaque myelogram. Arrow points to a large filling defect in the opaque column. Ordinarily, a laterally placed ruptured disc does not produce such a large deformity.

Fig. 9. Case 3. Pantopaque myelogram. Arrow points to the obliterated axillary pouch at C5. This deformity is characteristic of a laterally placed ruptured disc pushing into the intervertebral foramen.

ROENTGEN EXAMINATION

Plain x-ray films of the cervical spine give invaluable evidence in many cases of ruptured cervical discs. The lateral films usually show narrowing of the interspace with loss of the normal lordotic curve even in a hyperextended position. Oblique views may show narrowing of the intervertebral foramen with proliferation of bone in the foramen (osteophytes). These proliferative bony changes

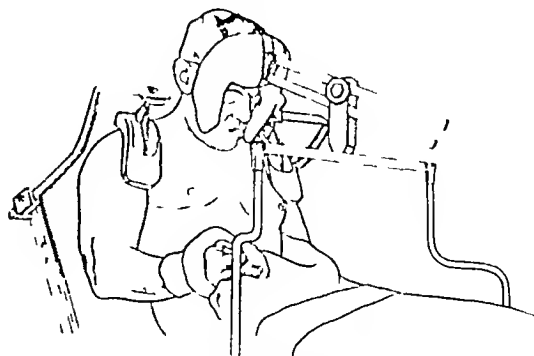


Fig. 11. Oblique view of patient in the upright position, using the head rest devised by Captain W. McK. Craig, M.C., U.S.N.R., Naval Medical Center, Bethesda, Md.

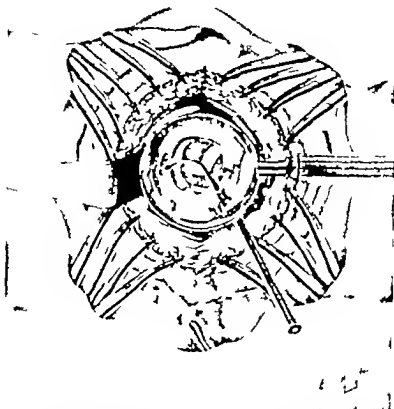


Fig. Drawing of operative field illustrating the exposure of the 6th cervical root with removal of bone. Not herniated nucleus pulposus protruding beneath the retracted nerve root.

may be bilateral even though the symptoms are unilateral.

Pantopaque myelography is an exceedingly accurate method of diagnosing ruptured cervical discs. In the prone position 6 cubic centimeters of pantopaque are injected into the subarachnoid space by lumbar puncture. Before tilting the table the patient's head is held in a fully extended position by placing a small pillow under the chin in order that the contrast material does not run into the basal cisternae of the skull. The head of the table is then tilted downward just enough to permit the pantopaque to collect in the cervical gutter. A series of anteroposterior films are then made after balancing the column at the desired level with the fluoroscope. The ante-

rior surface of the cervical canal is outlined clearly and each nerve root with its axillary pouch may be accurately identified. Larger lesions show a defect in the column (Fig. 8). Smaller lesions may show no defect other than an obliteration of an axillary pouch and root sleeve (Fig. 9).

TREATMENT

Conservative measures undoubtedly have an important place in the treatment of ruptured cervical intervertebral discs, particularly if the symptoms are purely radicular with no evidence of cord compression. If the lesion is suspected of being a fairly large one (as indicated by muscular wasting or marked sensory loss in the arm with or without signs of spinal cord defect)

then prompt operative intervention is advisable because of the dangers of irreparable damage to the cervical cord.

For the milder cases, a period of bed rest with halter traction may give lasting relief. The patient should have absolute bed rest and from 5 to 10 pounds of traction applied continuously. If after 3 or 4 days there is no relief of radicular pain and muscle spasm, further conservative treatment will probably be of little avail. If the patient is comfortable in traction and the pain recurs mildly when weight-bearing is resumed, a well fitting cervical collar support may give symptomatic relief.

Manipulation of the cervical spine in the presence of a ruptured intervertebral disc is a dangerous procedure and may result in irreparable damage to the spinal cord.

Operative technique The upright position is ideal for operations in the lower cervical region (Figs 10 and 11). Proximal nerve block or endotracheal ether anesthesia is equally satisfactory.

A straight incision is made from the spinous process of the vertebra above to the one below the level of the lesion. The muscles are freed from the spinous processes on the side of pain and, after denuding the laminae of soft tissue, a triangular piece of bone is removed from the laminae above and below the lesion with a small dental chisel. This exposes the ligamentum flavum which in the lower cervical region is almost completely covered with bone. The inner edge of the articular facet is then chiseled away thus providing good exposure of the root and the lateral edge of the dura mater covering the cord (Fig. 12). If the bony incision is placed correctly even the pre-dural fat need not be disturbed. The spinal root will be found to be wedged tightly into the intervertebral foramen by the anterior mass. With careful dissection, the root is separated from the mass and retracted either upward or downward in order that the mass may be removed with as little trauma to the root as possible. In case of the "soft" disc, bits of typical herniated nucleus pulposus may be lifted out of the tear in the annulus fibrosus. If the lesion is an old one and has become surrounded by a bony spur, it may be necessary

to chisel away the spur and remove the base of it with a curette. Then the posterior rim of the intervertebral foramen is removed completely with a nasal punch in order that complete decompression of the involved nerve root is provided.

After all bleeding is carefully controlled the usual anatomical closure of the wound is carried out by means of interrupted sutures of black silk.

Postoperative treatment The patient is kept in the recumbent position just so long as there is residual pain in the arm and shoulders. Some patients are comfortable immediately, while others have rather severe radicular pains for several days. A number of our cases have been out of bed on the first postoperative day, others have not been able to bear weight without pain for 10 to 12 days. With the operation performed in this manner, there is very little damage to the weight-bearing structures of the neck and, therefore, early ambulation is not considered harmful.

RESULTS

Of the 12 patients operated upon, all have been relieved of their radicular pain within 2 weeks following operation—most of them earlier. In each instance (with the exception of the last one who was operated upon but 3 weeks ago) the patients have been able to return to military duty without disability.

OBSERVATIONS

The true or relative incidence of ruptured cervical discs cannot now be stated because of insufficient data. Our experiences with both cervical and lumbar ruptured discs at the Walter Reed General Hospital indicate that the relative frequency of the two lesions is 1:12, i.e., there were 12 cervical and 143 lumbar ruptured discs verified by operation during the first 11 months of 1943. During this same period of time, there were many more clinical diagnoses made of lesions in both locations, but since they were not verified by operation no attempt was made to use them statistically. When the clinical features of ruptured discs in the cervical region are as well understood as are those in the lumbar regions this ratio will probably be reduced.

The statistical analysis of data in Table I discloses some pertinent details requiring further emphasis.

1. There was but 1 patient under 30 years of age (28 years) and there were patients aged 40 years or older. This would indicate that the cervical disc lesions occur more frequently in the upper age group. This is in contrast to the ruptured lumbar discs as seen in the personnel of the military service where age or physical fitness appears to be of minor significance.

2. There were but 2 patients (16%) who gave histories of trauma precipitating the onset of symptoms. This, again, is in contrast to the lumbar disc lesions in which a history of trauma is obtained in approximately 60 per cent of cases.

3. Pain and paresthesias radiating from the neck into the shoulder arm and hand were constant findings. Moreover these symptoms were consistently exaggerated by the neck compression test—a sign that we consider to be almost pathognomonic of a laterally placed ruptured cervical disc.

4. Twice as many ruptured cervical discs occur at the 6th interspace as at the 5th interspace. In our series, there were 8 at C-6/3 at C-5 and in 1 instance, there was a lesion at both C-5 and C-6. The diagnosis of the double disc (Case 5) was made on clinical findings verified by pantopaque myelogram, and proved at operation.

SUMMARY

1. Lateral rupture of the lower cervical intervertebral discs is a common cause of radicular pain affecting the upper extremity.

2. The clinical syndrome is remarkably constant and easily recognized.

3. Accurate localization of the lesion on clinical findings is usually possible. The salient features are:

The 5th cervical disc. (a) Pain radiating from the neck into the shoulder and arm with paresthesias (needles and pins or numbness)

into the posterior aspect of the thumb. Symptoms always aggravated by tilting the head to the painful side. (b) Weakness or absence of the tendon reflex of the biceps brachialis muscle.

The 6th cervical disc. (a) Pain radiating from the neck into the shoulder and arm with paresthesias (needles and pins or numbness) into the index middle and perhaps the ring fingers and tip of thumb. Symptoms aggravated by tilting head to the painful side. (b) Weakness or absence of the tendon reflex of the triceps brachialis muscle.

4. The lesion can in most instances be accurately verified by pantopaque myelography.

5. Conservative treatment relieves symptoms in many cases. When conservative measures fail, operative removal of the lesion is justified on the basis that it is a simple safe procedure and the results are excellent.

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AN EXPERIMENTAL STUDY OF SULFONAMIDE IMPREGNATED SUTURES

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RECENTLY there has been much experimental and clinical work carried out concerning the local uses and action of the sulfonamides. Because of the beneficial effects consistently reported with the local employment of sulfonamides in contaminated wounds, and since suture material so many times is a factor in wound infection, we decided to determine whether or not absorbable and nonabsorbable sutures impregnated with sulfonamides would reduce the incidence or severity of surgical wound infections.

Ochsner and Meade, after studying various suture materials embedded in surgical wounds, concluded that cotton was the most satisfactory of all, since it produced a minimal tissue reaction in contrast to the "wet" or "proliferative" reaction caused by catgut. They also observed that infection occurred more often when catgut sutures were employed. However, those who have worked with nonabsorbable sutures are not unaware of their outstanding disadvantage, namely, that when infection occurs in a surgical wound closed with such sutures the regenerative process is prolonged, and healing will not take place until all the infected sutures are either removed or extruded through a sinus tract. Keeping this fact in mind, the writers undertook experiments using sulfonamide impregnated sutures, hoping to determine whether or not the incidence and degree of infection would be lessened when contaminated wounds were closed with such sutures or had them buried in the wound.

In noncontaminated surgical cases as in laparotomies and hernioplasties, it is not uncommon for wound infections to form despite the strictest aseptic precautions, and most often these infections are found to take place

in the subcutaneous layer of the abdominal wall. Because of this observation, we planned to reproduce experimentally a similar infection in the abdominal wall of the dog. Also, since *Staphylococcus aureus* is known to be the most frequent causative organism found in surgical wound infections, we selected for our experiments a strain of hemolytic *Staphylococcus aureus*¹ isolated from contaminated human blood in a blood bank. The suture material employed in this study consisted of No. 20 cotton, containing 10.5 per cent sulfadiazine by weight, No. 20 cotton containing 44.2 per cent sodium sulfathiazole sesquihydrate, No. 0 catgut containing 4.6 per cent sulfanilamide, and No. 0 catgut containing 2.3 per cent sulfathiazole. In the control wounds, we employed sutures that were identical in every respect, except that they were not impregnated with sulfonamides. There were no obvious differences noted in the tensile strength between the impregnated sutures and our controls.

To proceed properly with our experiment, in which a comparative study of the merit between impregnated and unimpregnated sutures was to be made, it was imperative that we first determine existing questions: the minimal concentration of *Staphylococcus aureus* required to produce consistently an infection in our surgical wounds and the traumatic effect of the ligatures used on the degree of infection and wound healing.

To maintain consistency in our observations, we believed that the evaluation of the

¹The *Staphylococcus aureus* was gram positive; it produced acid in muhin, sucrose, lactose, maltose, dextrose, and mannitol broth and was dilute negative and hemolyzed blood. The virulence of the bacterial strain was checked on several occasions by injecting 0.2 c.c. of a 1:10 dilution of a 24 hour broth culture into uninjured subcutaneous tissue of the abdominal wall of rabbits. These rabbits developed localized reddened, swollen areas up to one half inch in diameter at the site of injection, while control injections of sterile saline solution produced no sign of local inflammation when examined after 48 and 120 hours. The cultures employed in these experiments were 22 to 24 hour broth cultures incubated at 37 degrees C.



Fig. 1. The dotted line represents the suture as it lies underneath the surface in the epidermal layer. The solid line illustrates the suture as it is seen lying on the surface of the wound. The vertical line represents the incision which has been made.

Incidence and the degree of wound infection should be based upon a standard set of criteria that would be applicable to all wounds. Our gross observations therefore included notations as to the presence or absence of redness, swelling, wound separation and the accumulation of serous or purulent material. The degree of bacterial growth was determined by making bacterial cultures of these wounds and then counting the number of colonies grown after a 24 hour incubation period. Then by employing the same criteria used by other workers, we decided further to evaluate wound infection and wound healing by taking biopsy specimens from each wound on the 6th post operative day in order to observe any differences that might exist microscopically. Here the presence or absence of edema, polymorphonuclear leucocytosis, giant cells, fibroplasia, fibrosis and capillary proliferation were particularly sought.

The technique employed in our experimental study to determine the dosage of bacteria required to produce wound infections consisted entirely in contaminated traumatized and untraumatized surgical wounds was as follows:

1. Each dog was anesthetized and the abdominal wall was shaved. The skin was painted with tincture of iodine and sterile drapes were applied.

2. A skin incision 2.5 inches long was made in each of the four quadrants of the abdomen and carried down as far as the anterior rectus sheath.

3. In each wound hemostasis was obtained by the use of 6 No. 20 plain cotton ligatures. In instances in which less than 6 ties were required for hemostasis, knots were purposely tied in the nonbleeding tissue to make up the same number. In the upper and lower wounds on the right side of the abdomen of



Fig. 2. A diagrammatic sketch of the course of the intracutaneous suture, demonstrating how in passing only through the epidermal layer it avoids becoming contaminated by the implanted organisms lying in the subcutaneous tissue.

each dog hemostasis was accomplished by the use of mosquito forceps, so that as little tissue as possible was crushed in the clamping. We considered these wounds to be "non-traumatized." However in the upper and lower wounds on the left side of the abdomen, hemostasis was accomplished by the use of large Ochsner hemostats so that an excess of tissue was included in the crushing. These left sided wounds we classified as "traumatized." Each of the 4 wounds were then closed by inserting 6 intracutaneous interrupted cotton sutures in such a manner as to avoid passing through the contaminated subcutaneous tissue. This special suture devised by Lieutenant Glassman (Figs. 1 and 2) had the advantage of confining our infections to the subcutaneous layer alone thereby preventing the infection from traveling along the course of the suture to the surface of the wound, or bacteria on the skin from secondarily invading the subcutaneous tissue or confusion of the microscopic picture due to reaction to the suture used in skin closure with the reaction to the suture employed for hemostasis.

4. Each wound was contaminated by introducing 0.2 cubic centimeter of a bacterial suspension of *Staphylococcus aureus* into the subcutaneous layer by means of a long sterile pipette. Collodion dressings and canvas binders were employed to prevent the animals from contaminating and removing the sutures with their teeth.

5. As stated previously gross inspections and bacteriological cultures were made of each wound after 48 and after 120 hours. A relatively quantitative method was used to determine the number of bacteria in the wounds. The technique involved the withdrawal of a given standard amount of serous material by means of a sterile glass capillary tube stro-

duced into the depth of the wound at the time of sampling. By the use of tubes of a uniform diameter the volume of sampling was kept constant throughout the experiments. Material allowed to enter the tubes at the time of sampling was kept constant throughout the course of the experiments. The amount of material withdrawn was inoculated into molten agar and poured into Petri plates. Colonies were counted after 48 hours of incubation at 37 degrees C.

6 Biopsy specimens were taken from each wound on the 6th postoperative day.

At times, individual variations in response to trauma and bacterial infection did occur but not with such frequency as to interfere with the interpretation of our preliminary experiments (determining the bacterial dose), which were as follows:

1 The lowest bacterial dilution capable of producing a wound infection consistently was found to be 0.2 cubic centimeter of a 1:1000 dilution of a 22 to 24 hour culture of *Staphylococcus aureus*.

2 The traumatized wounds showed much poorer healing than those that were not traumatized as was evidenced by gross, bacteriologic, and microscopic examinations.

3 By microscopic comparison of the wound biopsy specimens, the traumatized ones were readily recognized by the presence of a greater collection of serum and polymorphonuclear leucocytes as well as a higher degree of necrosis.

Having succeeded in establishing a standard dose of bacteria which would result in artificially induced infection with a minimal amount of contaminant and trauma, we proceeded with our study to determine whether or not sutures impregnated with sulfonamide compounds would reduce materially the degree of bacterial growth, or favorably influence the course of healing of a contaminated wound. Four groups of experiments¹ were arranged. In the 1st group we used No. 20 cotton sutures impregnated with sulfadiazine, in the 2d group No. 20 cotton sutures impregnated with sodium sulfathiazole sesquihydrate, in the 3d group No. 0 catgut impregnated with sulfia-

¹The suture material used in these experiments was kindly prepared according to our specifications by Curity Suture Laboratories of Bauer & Black, Division of Kendall Company.

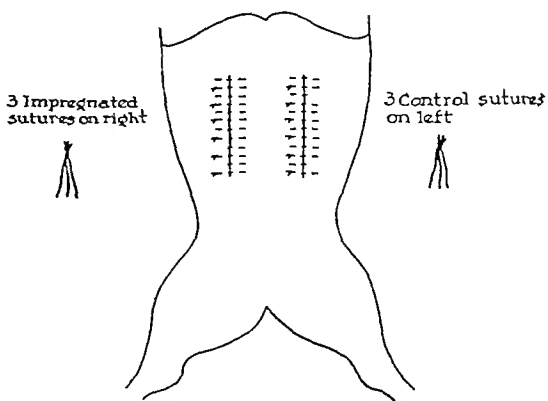


Fig. 3. A skin incision 5 inches long is made on either side of the midline. Three 5 inch strands of the impregnated suture to be tested, knotted together at one end, are laid in the right wound while 3 strands of the suture controls are placed into the left wound. Six intracuticular mattress stitches are used to approximate the edges of each wound as shown in Figures 1 and 2.

nilamide, and finally in the 4th group No. 0 catgut impregnated with sulfathiazole. With each group, controls were run in which identical unimpregnated sutures were used.

Since a moderate increase in the amount of trauma associated with closure of the wound reflected so sharply in the rate and type of healing (a fact which after all is quite well known), we decided to embed strands of suture material rather than knots, since it would be difficult or impossible to include the same amount of tissue with the ligature in each of the experiments. In other words it appeared that we could standardize the experiments better by excluding trauma as much as possible.

The technique employed in our experimental study of artificially contaminated wounds in which sulfonamide impregnated sutures were embedded, was carried out as follows:

1 Each dog was anesthetized and the abdominal wall was shaved. The skin was painted with tincture of iodine and sterile drapes were applied.

2 A skin incision 5 inches long was made on either side of the midline and carried down to the anterior rectus sheath, as illustrated in Fig. 3. Hemostasis was obtained by grasping as little tissue as possible in our clamps and employing the same number of ligatures in each wound.

3 Three 5 inch strands of the impregnated suture to be tested knotted together at one end, were laid in the right wound while 3 strands of control suture (not impregnated) were placed in the left wound. Six intracuticular mattress stitches as seen in Figures 1 and 2 were used to approximate the edges of each wound.

4 The wounds were then contaminated by introducing by means of a long pipette 0.2 cubic centimeter of broth cultures of *Staphylococcus aureus* either undiluted or diluted 1:10 and 1:100 with physiological saline. Colloid dressings and canvas binders served in preventing injury and contamination from extraneous sources. The examination of these wounds, as in the aforementioned experiments, were carried out after 48 and after 120 hours.

In part A of group 1 experiment No. 20 cotton sutures impregnated with sulfadiazine were embedded in surgical wounds contaminated with a 0.2 cubic centimeter of undiluted culture of *Staphylococcus aureus*. The following observations were made:

1 Examination of wounds containing untreated and impregnated sutures, after 48 hours showed no gross differences except for the presence of more serum in the wounds containing the untreated sutures. But bacteriologic examinations revealed a reduction in the number of bacteria present in the wounds that contained the impregnated sutures.

2 Examinations after 120 hours revealed that the wounds containing the impregnated sutures appeared more normal than the wounds containing the untreated controls, as was evidenced by the smaller amount of serum, reduced bacterial count and a lesser number of microscopic signs of infection.

In part B of group 1 experiment No. 20 cotton sutures impregnated with sulfadiazine were embedded in surgical wounds contaminated with 0.2 cubic centimeter of a 1:10 dilution of a culture of *Staphylococcus aureus*. The following observations were made:

1 Although there were no gross differences observed between the wounds containing plain cotton and those containing sutures impregnated with sulfadiazine the bacterial cultures of the wounds containing impregnated sutures showed very noticeable reductions in

their bacterial counts. In fact we were able consistently to demonstrate a reduction in the bacterial count of approximately 50 per cent. Though no gross differences were noticed even after 120 hours, our cultures still showed a reduction of 60 per cent or more in the number of bacteria present in the wounds containing sutures impregnated with sulfadiazine.

2 The microscope examination of wounds containing impregnated sutures further revealed that improved healing had taken place. This fact was evidenced by the smaller amount of serum present, fewer polymorphonuclear leukocytes, minimal necrosis, and a demonstrable increase in fibroplasia when compared with wounds containing untreated control sutures.

3 Examination of wound biopsy specimens after 14 to 21 days revealed that wounds containing impregnated sutures still possessed more advanced healing. The concentration of sulfonamide present in our suture material was in no case sufficient to produce any noticeable foreign body reaction.

In part C of group 1 experiment No. 20 cotton sutures impregnated with sulfadiazine were embedded in surgical wounds contaminated with 0.2 cubic centimeter of a 1:1000 dilution of a culture of *Staphylococcus aureus*. The following observations were made:

1 After 48 hours there were no gross differences noticed between those wounds containing untreated cotton sutures and those containing sulfadiazine impregnated cotton sutures. However bacterial cultures taken from wounds containing the untreated sutures revealed the presence of slight bacterial infection, while cultures taken from the wounds containing the impregnated sutures were sterile.

2 After 20 hours, bacterial cultures revealed that the wounds containing untreated cotton sutures were still infected while the wounds containing sutures impregnated with sulfadiazine remained sterile. Here again the microscopic examinations of the wounds containing impregnated suture material showed a slight, but definitely better healing.

From these findings we concluded that the presence of sulfadiazine in cotton suture material appears to be capable of preventing or

minimizing infection following inoculation of the wound with staphylococci as described. Although no gross improvement of wound healing was apparent, microscopic examinations of the wounds containing unimpregnated control sutures revealed definite evidence of retarded healing.

In group II experiment No. 20 cotton sutures impregnated with sodium sulfathiazole sesquihydrate were embedded in surgical wounds contaminated with 0.2 cubic centimeter of a 1:10 dilution of a culture of *Staphylococcus aureus*. The following observations were made:

1. The gross and microscopic findings were practically the same as those obtained with sutures impregnated with sulfadiazine, as described in part B of group I. In addition, the sutures impregnated with sodium sulfathiazole sesquihydrate showed a reduction in the bacterial count of over 75 per cent in most instances.

In group III experiment No. 0 catgut sutures impregnated with sulfanilamide were embedded in surgical wounds contaminated with 0.2 cubic centimeter of a 1:10 dilution of a culture of *Staphylococcus aureus*. The following observations were made:

1. After 48 hours no gross differences were seen between the wounds containing untreated catgut sutures, and those in which impregnated sutures were embedded. Cultures taken at this time from the wounds containing the impregnated catgut showed a reduction in the bacterial count of about 50 per cent over cultures taken from wounds containing untreated catgut controls. Surprisingly enough, after an interval of 120 hours, cultures obtained from the wounds containing the im-

pregnated sutures gave a higher bacterial count while the microscopic findings revealed evidence of poorer healing. These observations led the writers to conclude that sulfanilamide impregnated catgut sutures afford only a transitory protection, if any, against bacterial infection.

In group IV experiment No. 0 catgut sutures impregnated with sulfathiazole were embedded in surgical wounds contaminated with 0.2 cubic centimeter of a 1:10 dilution of a culture of *Staphylococcus aureus*. The following observations were made. The sulfathiazole impregnated catgut sutures in surgical wounds proved just as disappointing as those that contained sulfanilamide. Here, again, we noticed that whatever bacteriostatic action they possessed was only transitory. In addition the microscopic picture showed a definite impairment of healing processes.

SUMMARY

The authors believe that these preliminary experiments with sulfonamide impregnated suture materials in infected wounds indicate that cotton sutures impregnated with sulfonamide compounds will reduce the growth of bacteria in minimally infected wounds and thereby favorably influence wound healing. On the contrary, catgut impregnated with sulfonamide exerts little or no beneficial influence on bacterial infection or wound healing. It is possible that the smaller amount of sulfonamide present in the catgut sutures may partially explain this observation though the nature of the suture material itself may be partially responsible. The importance of trauma upon bacterial infection and wound healing is reaffirmed.

SOLITARY CIRCUMSCRIBED TUMORS OF THE LUNG

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THE more common bronchogenic neoplasms arise in the major bronchi and if untreated usually progress to obliterate the bronchus causing atelectasis of the distal lung (Fig. 1). This gives rise to a definite train of symptoms which usually consist of a dry hacking cough, followed soon by hemoptysis, shortness of breath, wheezing, chest pain and fever. As metastases occur the usual symptoms of anorexia, weakness, and weight loss typical of all extensive malignancies appear. Occasionally distant metastases, especially to bones, brain or abdomen cloud the picture by causing more troublesome symptoms than those produced by a small primary lesion in the lung. There is, however, a group of primary lung tumors that arise in smaller peripheral bronchi. They give rise to a rather indefinite group of symptoms, have a characteristic x-ray picture and are rather easily confused with solitary metastatic tumors, and infections in the lung. This type of tumor may also simulate mediastinal and chest wall neoplasms. These solitary circumscribed lung tumors constitute about 25 per cent of all primary lung tumors. Included in this discussion are 23 patients seen at the University of Chicago Clinics in the past 10 years with a solitary rounded lesion in the lung that was at least 2 inches in diameter and at some time in the course of the illness was considered to be a neoplasm. We have included only patients in whom microscopic proof of the diagnosis was obtained or those in whom certain clinical features make the diagnosis fairly certain.

The characteristic x-ray appearance of these lesions is a solitary rounded, dense mass in the lung. Usually the borders of the tumor are very sharp but this feature may be obscured by the proximity of the lesion to the

mediastinum or chest wall. Occasionally a cavity within the tumor (Fig. 2) is visualized (5, 7).

The symptoms in this type of lung tumor are varied. Table I contains the chief complaint of the 23 patients in this series. The most striking features demonstrated are the lack of cough and the relative infrequency with which the presenting complaint gave the clue that the primary pathology was in the lung. In 6 of the group there was no obvious complaint. Pain in the chest was most commonly present, but was seen in less than one third of the patients and probably occurred late in the course of the disease. Cough was the main complaint in only 5 patients, 2 of whom had cavitory carcinomas. Four patients had marked weight loss and 1 presented himself because of clubbing of the fingers. Table II listing the more common symptoms illustrates the same points. In addition it shows that the symptoms of advanced disease (viz. weight loss, weakness, and anorexia) were very prominent features. Only 5 patients in the entire series had hemoptysis. It is interesting that 5 individuals noticed clubbing of their fingers. Also it is worthy of note that 3 patients had an illness diagnosed as pneumonia in the course of their disease, despite the fact that the lesion was circumscribed and in the periphery. Further evidence of the variable nature of the onset of the disease is that only 21 of the 23 patients were admitted to the medical or surgical chest clinics.

Physical findings can best be dismissed with the statement that they were extremely variable and often absent. About half of the patients had abnormal findings in the chest but in none were the findings diagnostic. The main value of physical examination in this type of case is to find metastases from a primary lung cancer or a primary tumor elsewhere, which is responsible for a metastasis to the lung.

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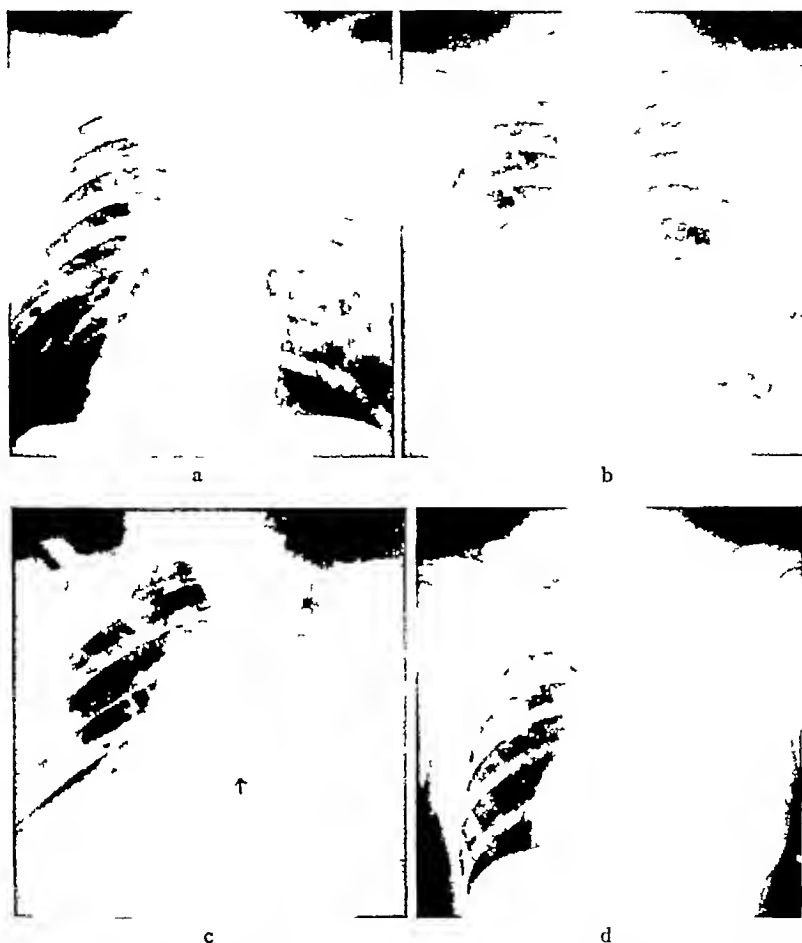


Fig 1 A series of chest roentgenograms to show the stages of bronchial obstruction in cancer of the lung a, X-ray film of the chest demonstrating the most common roentgenologic finding in bronchogenic carcinoma, viz, a diffuse, irregular area of atelectasis in the right upper lung field b, Collapse of the left lower lung lobe with a triangular shadow near the heart in a patient with a squamous cell carcinoma arising in the bronchus of the left lobe c, Iodized oil injection of the tracheo-bronchial tree, localizing obstruction in the right middle and lower lobe bronchi Arrow points to the puddling of oil d, Roentgenograms of the chest in an individual with complete collapse and infiltration of the right lung due to bronchogenic carcinoma Clinically and at autopsy there was no fluid in the pleural space

Table III lists the diagnoses in this group of patients Seventeen of the 23 rounded opacities demonstrated on x-ray examination were malignant lung tumors Only 3 were metastatic, 14 were primary in the lung One patient had a benign lung tumor Such a tabulation emphasizes 3 important points First, so called cannon-ball tumors of the lung, if seen as solitary lesions, are most likely primary in the lung Second, metastatic tumors

to the lung are usually multiple when demonstrated clinically About 30 multiple metastatic tumors of the lung are seen at this clinic yearly (10) but in the past 10 years only 3 solitary metastases to the lung have been definitely demonstrated Third, highly differentiated neoplasms were relatively common among the primary lung tumors There was only 1 sarcoma and 4 undifferentiated carcinomas One patient with a squamous cell

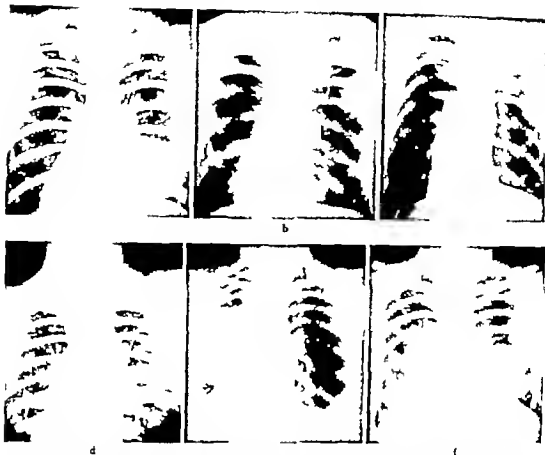


Fig. 2. A series of circumscribed tumors primary within the lung. a, Primary adenocarcinoma in the base of the right lung. b, Primary squamous cell carcinoma in the right upper lung field. This lesion had been followed 3 years when this film was taken. c, Cavitary lesion in the right apex simulating tuberculosis. This is primary

bronchogenic carcinoma. d, Cavitary carcinoma of the right lower lobe. e, Large malignant epidermoid, that started out of the lung field with a cyst. However the patient later died of recurrence. f, bronchus of lung simulating mediastinal tumor. At operation there were widespread metastases throughout the left pleural space.

cardioma was followed 3 years before an operation was done to remove the tumor.

The most common error made in this series was in the diagnosis of tuberculosis. Two patients were operated on for a solitary circumscribed lesion which was later found to be a tuberculosis. In another 2 patients we were able to make the clinical diagnosis of tuberculosis because of calcium deposits in the lesion. One patient had a chronic lung abscess that could not be differentiated from tumor before operation.

It is obvious from our discussion that at times we had considerable difficulty in arriv-

ing at a logical preoperative or antemortem diagnosis. We have already indicated that the clinical history and physical examination were of less aid than is usually the case in diseases of the chest. The age of the patient was of some value after the presence of an obvious lesion in the lung was ascertained.

Fluoroscopic and x ray examinations demonstrated every tumor in the series and gave some clues as to the type of the lesion. Calcification within the lesions indicated tuberculous. Position within the chest with respect to the anteroposterior diameter localized some lesions within the mediastinum. Sputum

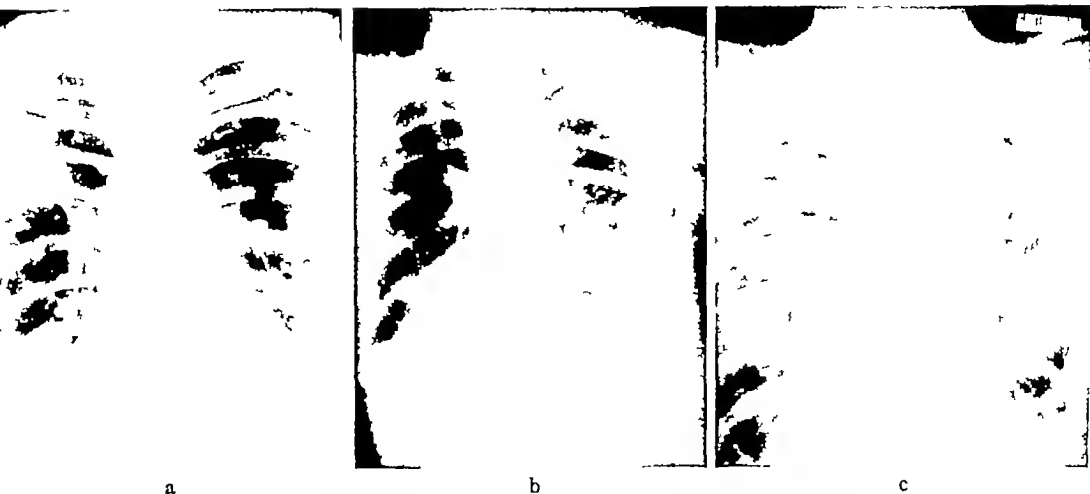


Fig 3 Circumscribed lesions that were not primary lung cancers a, Tuberculosis of the right upper lobe which was resected before a diagnosis could be definitely established b, Metastatic sarcoma from the uterus, diagnosis substantiated at autopsy c, Cavitory lesion in the right apex (see arrow) that could be tuberculosis or tumor This was a chronic pyogenic lung abscess that healed following drainage

examinations were made routinely Cultures and examination for tubercle bacilli were done, however, in none of the 4 cases of tuberculosis were tubercle bacilli demonstrated, and no specific organism was found in the patient with a chronic lung abscess Guinea pig inoculation of the sputum was positive in 1 case Microscopic sections of the sputum to detect tumor cells was occasionally done but was not conclusive

Bronchography was done in several patients and was often a distinct aid in localizing the lesion within the lung, in contrast to mediastinal lesions Bronchoscopy was done in 12 patients, but in only 2 was a positive biopsy obtained Examination of the pleural fluid (none present), aspiration biopsy, diagnostic pneumothorax, and thoracoscopy were not done in this group of patients

In view of the difficulty of diagnosis in this type of case it is interesting to review the procedures that actually led to the correct diagnosis (Table IV) In 4 patients the diagnosis was made on the basis of history, physical findings and x-ray examination Two of these were patients who demonstrated calcium in asymptomatic lesions A diagnosis of tuberculosis was made, and the clinical course of the patients substantiated this impression The third patient had a hypernephroma of the

kidney No histological preparation was made of the lung lesion, but since the patient died soon after it appeared, it almost surely was metastatic from the kidney The fourth patient had a benign lung tumor (hemangioma) that was suspected on the basis of polycythemia, cyanosis, and clubbing of the fingers and toes, in the absence of heart disease and pulmonary fibrosis This diagnosis was substantiated at operation

In 2 patients with lung cancers a positive biopsy was obtained at bronchoscopy These 2 patients and the 4 here described were the only ones in which we could be absolutely sure of the diagnosis before operation or autopsy, although in many of the cases the correct diagnosis was suspected In 7 patients the diagnosis was made at autopsy In 5 of this group the diagnosis was considered during life, but in 2 the lung tumor was unsuspected before autopsy In 10 individuals a diagnosis of probable lung tumor was made and exploration of the chest was done In this group there were 5 primary carcinomas of the lung, 2 tuberculomas, and 1 each of chronic lung abscess, sarcoma, and malignant epidermoid

The almost complete failure of our usual aids to make an accurate diagnosis in these cases suggests very strongly the use of early exploratory thoracotomy as a diagnostic pro-

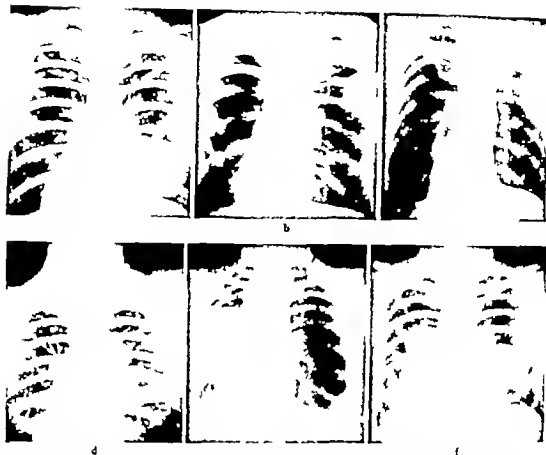


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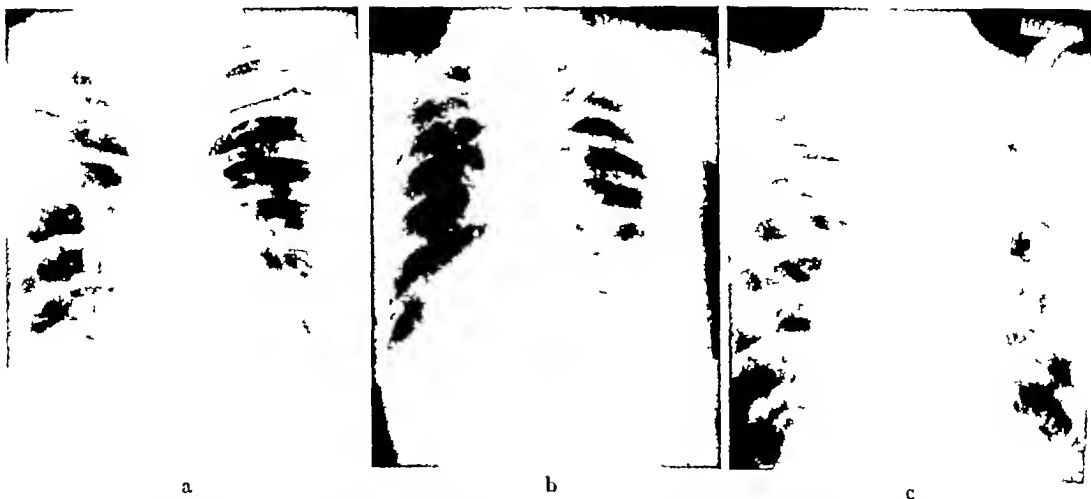
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a

b

c

Fig 3 Circumscribed lesions that were not primary lung cancers: a, Tuberculosis of the right upper lobe which was resected before a diagnosis could be definitely established; b, Metastatic sarcoma from the uterus, diagnosis substantiated at autopsy; c, Cavitory lesion in the right apex (see arrow) that could be tuberculosis or tumor. This was a chronic pyogenic lung abscess that healed following drainage.

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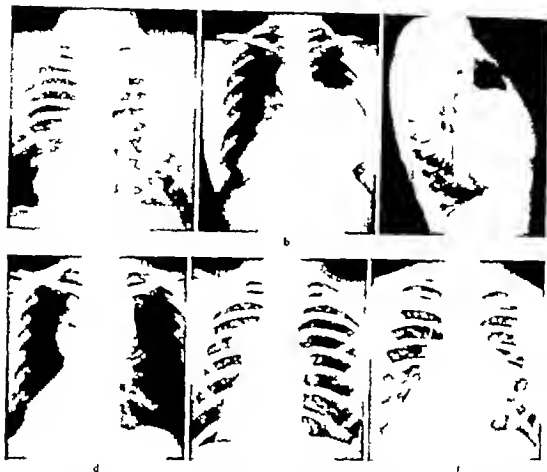


Fig. 4. Mediastinal tumors that could be confused with primary lung tumors. a, Bronchial cyst of the superior mediastinum removed at operation. b, Dermoid of the anterior mediastinum. c, Lateral view of b, shows the anterior position of the tumor. d, Aneurysm of the aorta.

that was diagnosed by calcification (arrow) in this all Mediastinal abscess (tuberculous) that could not be diagnosed before exploration of the chest. f, Neurofibroma of the mediastinum placed far posteriorly in the vertebral gutter.

cedure. When properly done a thoracotomy carries as little morbidity and mortality as exploratory laparotomy. Since our figures show that most of these lesions will be primary lung cancers, surgical treatment at the earliest possible date is the procedure of choice. Actually removal of a solitary metastatic lesion in the lung may be reasonable when the primary tumor is also resectable (2, 8). Excision of solitary tuberculomas gives very favorable results (3, 4, 9). If a chronic pyogenic infection in the lung is found the incision is closed and local drainage done at a later date when the pleura becomes bilateral.

DIFFERENTIAL DIAGNOSIS

Primary tumors of the lung in general can usually be differentiated from metastatic tumors at bronchoscopy (6). The primary tumor arising within the bronchus is usually easily subjected to biopsy but metastatic tumors occur in the parenchyma and are not visible on bronchoscopy. However the lesions in this series arose far out in the lung and even when primary in the lung very few could be seen through the bronchoscope. Actually about the only way to diagnose a metastatic tumor was to find the primary lesion.

TABLE I —PRESENTING COMPLAINTS WHEN FIRST SEEN IN THE OUT CLINIC

Complaints	No
Pain in chest	7
None	6
Cough (productive)	5
Weight loss	4
Clubbing of fingers	1
Total cases	23

Circumscribed tumors can often be distinguished from solitary tuberculous lesions. In some cases of tuberculosis, there will be other evidence of acid-fast infection in the lung fields or calcification within the lesion itself. Calcification is never seen in a malignant lung tumor, although it may be present in benign lung tumors. If a positive sputum can be obtained, the diagnosis is obvious although both neoplastic and tuberculous lesions may coexist.

A word of caution is in order regarding the presence of cavitation in the absence of acid-fast bacilli. Practically all tuberculous cavities of any size will produce a positive sputum unless they are the so called "closed" cavities. If a cavity is demonstrated and no tubercle bacilli are found, a neoplasm must be strongly suspected. If no tumor is found at bronchoscopy and acid-fast bacilli are absent in the sputum, the diagnosis of a primary pyogenic infection in these cavity lesions is usually made by exclusion. Although cultures are made, they seldom lead to the correct diagnosis. Most often these chronic lung abscesses, in the absence of a definite history, can be diagnosed only by biopsy at thoracotomy.

Mediastinal lesions offer the greatest problems in differential diagnosis and although it is possible to diagnose a tumor of the medi-

TABLE II —MOST COMMON SYMPTOMS IN THIS SERIES

No	Symptoms	No	Symptoms	No
12	Weight loss	12	Pneumonia	3
10	Cough	10	Bone pain	2
10	Chest pain	10	Asthma	1
9	Weakness	9	Cyanosis	
6	Anorexia	6	Hematuria	
5	Hemoptysis	5	Conj.	
5	Clubbing fingers	5		

astinum before operation in many cases, in at least half of the patients seen, it is necessary to explore the lesion to make an accurate diagnosis. Tumors of the anterior mediastinum usually offer little difficulty. Dermoids may attain a large size before they are seen, and a lateral film of the chest showing the lesion placed far anteriorly is usually sufficient to make the diagnosis. Substernal thyroid can often be demonstrated to have a connection with the thyroid gland in the neck and they may be associated with signs of toxicity. In the midportion of the mediastinum the most common lesion is one type of the lymphomas. Only rarely do these lesions assume a circumscribed solitary appearance, although occasionally such a lesion may give rise to considerable confusion in the diagnosis. Aneurysms occasionally will have calcification in their walls and most often the symptoms and findings of associated cardiac or vascular disease will lead to the correct diagnosis. Expansile pulsations will also prove the diagnosis if the blood in the aneurysm is not clotted. Bronchogenic and gastric cysts from their x-ray appearance alone may exactly duplicate primary lung tumors, but they usually occur in a patient who has no symptoms and who seems to be in good health. Low-grade mediastinal abscesses, unless they connect with the bronchus to produce symptoms, usually cannot be distinguished from primary lung tumors. Metastatic tumors

TABLE III —FINAL DIAGNOSIS¹

Diagnosis	No patients	Diagnosis	No patients
Primary lung tumor	(15)	Metastatic lung tumors	(3)
Squamous cell carcinoma	4	From kidney	2
Adenocarcinoma	4	From uterus	1
Carcinoma (untyped)	4	Tuberculosis	(4)
Sarcoma	1	Chronic lung abscess	(1)
Malignant epidermoid?	1		
Hemangioma	1		

¹Ascertained by operation, autopsy, bronchoscopy or the clinical course of the patient.

TABLE IV —METHODS USED TO ESTABLISH DIAGNOSIS IN OUR SERIES

Method	No patients
Exploratory thoracotomy	10
Autopsy	7
a Suspected clinically	5
b Unsuspected	2
Clinical characteristics	4
Bronchoscopy	2

from bone breast testes and kidney to the midportion of the mediastinum are correctly diagnosed by having knowledge of the primary lesion. Neurofibroma in the posterior mediastinum can easily be distinguished by fluoroscopy or a lateral x-ray picture showing the lesion placed far posteriorly in the vertebral gutter.

Finally chest wall tumors give rise to very little difficulty in differential diagnosis. They most often show evidence of rib destruction, calcification within the lesion or are palpable externally.

TREATMENT AND RESULTS

Some statement probably should be made as to the treatment and final outcome in these patients. There were 4 instances of primary squamous cell carcinoma in the lung. One patient died 2 weeks following operation of cardiac failure after a seemingly successful removal of the tumor. Two patients were explored and found to be inoperable and are now deceased. One individual survived a pneumonectomy 1 year ago and is now well. Two of the 4 patients with adenocarcinomas received x-ray therapy and are now deceased. One patient had a successful pneumonectomy 10 months ago and is well without evidence of recurrence. One patient died of recurrence following lobectomy. All 4 patients with untipped carcinomas were explored and found to be inoperable. They died within a year after operation. The patient with the sarcoma was explored and found to be inoperable. X-ray therapy was given but the man died. The malignant epidermoid was successfully resected but the patient died about 10 months later of recurrence. The 1 benign tumor (the meningioma) survived a pneumonectomy 6 months ago and is seemingly cured. All 3 patients with metastatic tumors are deceased.

The 4 patients with tuberculosis are alive and all but 1 are considered well. The patient with a chronic pyogenic lung abscess is entirely asymptomatic.

SUMMARY AND CONCLUSIONS

1. A group of 23 patients with solitary circumscribed opacities in the lung have been presented.

2. These lesions are characterized by definite symptoms and physical findings and failure of the usual diagnostic aids to establish the correct diagnosis.

3. In our experience exploratory thoracotomy was the surest method by which an accurate diagnosis could be made and this procedure is recommended as an early diagnostic aid because it leads to early treatment.

4. Occasionally circumscribed opacities in the lung are tuberculomas or chronic lung abscesses, but most often they are primary lung cancers.

5. Solitary metastatic tumors of the lungs are relatively rare.

6. Methods of differential diagnosis, particularly from mediastinal and chest wall tumors, are discussed.

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PYOGENIC COXITIS

I End-Results and Considerations of Diagnosis and Treatment

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DURING the past few years, the authors have seen so many fortunate results following pyogenic infection of the hip that it has been difficult to reconcile them with the general pessimistic attitude recorded in the medical literature. In acute cases, suppuration often has been followed in our experience by a stable and painless hip, and motion has just as frequently been preserved, especially when early and careful treatment has been applied. We have, therefore, analyzed the end-results of 132 cases¹ available to us with a view of determining the factors that would lead to the best functional results following suppuration in the hip joint. In the course of this study, it became apparent that one of the most important factors was age. The hip joint reacts differently to pyogenic infection, depending upon the amount of cartilage present in the hip. This, in turn, is a function of age. The bearing on long term end-results of the controversial points of hip joint drainage and methods of after-care by plaster or traction has never been accurately evaluated. It is of importance to try to determine the factors which will lead to a desirable end-result: be it a stable hip secured by bony ankylosis in good position or a movable hip with restricted motion, stabilized by the remaining portion of the femoral head and neck. The methods aimed at securing the latter result, which is ideal, should receive attention both in the

acute stage and in later stages when suppuration has long since subsided. An unstable hip, by which we mean both the type where structural support has been lost and the type rendered unstable in unilateral weight-bearing by muscular dysfunction (Trendelenburg test), is unsatisfactory, since it produces an unsightly gait, even when both lower extremities are of equal length. Most of the literature dealing with acute and chronic pyogenic infections of hip joints is of little value in analyzing end-results because of the lack of accurate and detailed case reports and because no follow-up is available.

Bergmann, in reviewing the subject of osteomyelitis of the pelvis, recognized the chronicity and disability that followed perforation of infection into the hip joint as a complication of osteomyelitis of this region. Monsaingeon and Peeremans recognized pyogenic hip involvement complicating osteomyelitis of the ilium and stated that ankylosis was always due to this complication. Klem, in his monograph on osteomyelitis, found suppurative coxitis in 15.2 per cent of all his cases and ascribed chronicity to the deep lying bone suppuration. Moulouguet first described the radiological alterations of diffuse joint space loss in acute hip infections of synovial type and pointed out that dislocation was most often due to loss of femoral bone.

Kortzeborn and Hesse reported upon acute suppurative arthritis. They came to the conclusion that arthrotomy of itself condemned a joint to ankylosis and also reported a high mortality. Nathan reviewed his experience with over 200 cases of acute and chronic osteomyelitis of the upper femur involving the hip joint. His conclusions, while important, are not without exception. This author believed it necessary to open surgically every hip joint in which suppurative products were found and that every metastatic hip joint in-

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²We have also inspected the roentgenograms or studied the records of 177 additional cases that became available after compilation of the statistical division of this study. Those cases add nothing to the facts and conclusions drawn from the original number of cases.

TABLE I.—SEX AND AGE GROUPS OF 137 PATIENTS WITH SUPPURATIVE COXITIS

Age of onset	Male	Female	Total
0-3 years			20
4-11 years	17	1	18
Adolescents and adults	20	4	24
Totals	37	5	42

fection was traceable to metaphyseal or epiphyseal bone infection. He believed streptococcus infection to differ radically from staphylococcus involvement both in prognosis and chronicity. As will be pointed out in a later section of this paper the extent of bone killed by the embolic process and the tendency toward dislocation of the femur determine the prognosis and chronicity. This author painted an unnecessarily black picture of the outlook in staphylococcus bone suppuration stating that massive bone necrosis and sequestration invariably resulted in recurrence and chronic suppuration. Inge and Liebolt reviewed the literature on the treatment of acute suppurative arthritis and reported on the late results in 36 cases treated by operation in the New York Orthopedic Hospital from 1918 to 1933. They emphasized prompt arthrotomy with drainage, traction and passive and active motion as most likely to produce a joint resembling the normal. Relatively few (4 of 20) acute suppurating hip joints subsequently became stiff under such a regimen. They did not study end results of stability of this joint in relation to bone destruction.

Blake Reich and Caldwell reviewed joint suppuration and gave a bibliography. The latter two authors emphasized the now well known relations of the hip joint capsule to the metaphyseal centers about the hip. These will not be described here except to give the details of age variations and to point out that

septic emboli lodging about the hip invariably lie within the joint except at the periphery of the enchondral zone of ossification for the greater trochanter and in the pelvic bones at a certain distance from the furta-acetabular zone. These anatomic facts explain the occurrence of certain rare forms of osteomyelitis that occur near the hip but which do not involve the joint. Caldwell believed that the lack of bone infection often leads to a good functional result but ankylosis or pathological dislocation resulted when bone was involved.

Slowick and Badgley and his associates have reported the largest series recently respectively 60 and 113 cases of septic hip. Slowick pointed out for the first time that acute purulent infections of the hip joint in infancy should be separated from those of childhood and adult life. The former as a group have shown early healing and freedom from recurrence, sequestration of bone and severe joint destruction. Both authors noted the favorable prognosis with early drainage, traction, and other diligent after-cure methods.

Slowick believed that bone involvement was never associated with streptococcus infection. About half of his group of patients recovered with a stable hip, the number being equal in the streptococcus and the staphylococcus groups. Badgley's study was a comprehensive analysis of 113 cases with attention to end-results in terms of age, the causative organism, the amount of bone involved and sequestered, drainage and the types of postoperative treatment employed. That most of the grave complications which have hitherto been associated with this condition are preventable was stressed by Badgley and will be substantiated later in this paper.

TABLE II.—SEX CORRELATED WITH INITIAL POINT OF INVOLVEMENT IN 147 SUPPURATIVE HIP

	Age of onset			Initial focus				
	0-3	Adolescents and adults	Totals	Pyemia	Femur	Diaph	Trochanter	Unknown
Males	44	17	61	10	21	18		12
Females	24		24		16	15		20
Totals	68	17	85	10	37	33		32

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TABLE III — ACF AND INITIAL FOCUS OF SUPPURATION

Initial lesion	Age of onset			Totals
	0-1	4-12	Adolescents and adults	
Synovia	2	6	0	17
Femur	10	25	10	45
Ilium	2	14	14	10
Iscium	0	0	2	2
Unknown	7	15	11	53
Totals	21	50	46	147

The fundamental work of Phemister showing that cartilage undergoes ready solution in a pyogenic exudate should be mentioned, since this mechanism produces the early termination and benign course of the suppurative arthritis of infancy which often results in prompt dislocation of the hip. He also demonstrated that pressure accelerated cartilage destruction in the presence of a pyogenic exudate. Traction combats cartilage and joint destruction by removing the pressure of joint surfaces, while drainage prevents excess accumulation of purulent material.

The incidence of suppurative coxitis can only be estimated. Of 1,041 admissions for pyogenic osteomyelitis seen at the University of Chicago Clinic among 210,000 patients in 11 years, 107 pyogenic hips were encountered in 94 cases. Among the first 3,000 orthopedic cases beneath the age of 21 years seen in the clinics of the Division for Handicapped Children of the Illinois State Department of Public Welfare, 40 ancient septic hips were found in 38 disabled children. In a census of crippled and deformed children in the State of Illinois made by the same agency 105 cases of this disorder were encountered among 27,000 crippled children beneath the age of 21 years (0.74 per cent incidence among crippled children). These estimates are abnormally weighted with chronic cases and cases originating from widespread osteomyelitis, since the general surgeon usually sees the patients of the acute group of cases. The sex and age

groups of the patients represented in this series of cases are given in Table I. The initial point of involvement, correlated with sex and age groups is given in Tables II and III. Males are more frequently involved than females, just as is the case in pyogenic osteomyelitis. In 94 of our cases in which the initial lesion could be determined accurately from a study of serial roentgenograms, an osteomyelitis focus could be demonstrated in the majority of cases (81.0 per cent). This is due to two factors. The probable greater number of chronic cases in which the history was subsequently traced back to the beginning of illness and the long time follow-up by serial roentgenograms of our acute cases. The follow-up period, and the frequency of observation during it have not been uniform in this present series of cases, but more than two thirds of the cases have been followed more than 10 years. Such a period provides

TABLE IV — ORIGIN OF INFECTION IN SUPPURATIVE COXITIS ACCORDING TO AGE AND INITIAL LESION

Source of infection	Age of onset			Total	Initial lesion				
	0-1	4-12	Adolescent and adults		Synovia	Femur	Ilium	Iscium	Unknown
Skin	1	14	11	26	2	5	8	0	11
Upper respiratory tract	5	9	2	17	5	6	0	0	0
Ear	1	12	2	15	1	0	2	0	4
Genitourinary tract	0	0	1	1	0	4	0	0	1
Osteomyelitis elsewhere	0	3	2	5	1	0	1	1	1
Direct infection	0	0	1	1	1	0	0	0	0
Unknown	11	40	25	76	3	28	10	1	27
Totals	22	78	47	147	17	45	50	2	53

TABLE V — CAUSATIVE ORGANISMS IN SUPPURATIVE COXITIS

	Age of onset			Totals
	<		Adolescents and adults	
<i>Staphylococcus aureus</i>			14	31
<i>Staphylococcus albus</i>				
<i>Staphylococcus haemolyticus</i> (8)		19		19
<i>Pseudomonas</i> type III				
Unknown	14		13	27
Totals	14	19	13	46

observations of end results that for the most part are stationary.

ETIOLOGY, SYMPTOMS AND EARLY DIAGNOSIS INCLUDING ROENTGEN FINDINGS

Infection of the hip and surrounding structures in this series of cases has occurred almost without exception through the blood stream. Infection by penetrating wounds is not frequently encountered since this is a deep lying joint. The origin of pyrogenic organisms has been the usual origin of infection in pyogenic osteomyelitis (Table IV). In 69 hips, data for which were available the origin of bacteria was from the upper respiratory tract including the mastoid process and the middle ear or from the skin in the majority of cases. Causative micro-organisms are given in Table V. The gonococcus was implicated by inference in only a few cases, possibly because fewer cultures were available in older persons which group was in the minority in this series. Usually our patients were in good general condition prior to the onset of the illness under discussion. An acute illness, symptomatic of the septicemia or bacteremia usually ushered in the disease. An insidious course more rarely obtained.

It should be pointed out here that the hip joint is unique. It is bordered at least by four metaphyseal zones all of which are definitely intracapsular. This includes the capital femoral epiphysis and the three pelvic metaphyses underlying the articular cartilage of the acetabulum in the ilium, ischium, and pubis. The exact relationship of these end artery zones and the epiphyseal and joint

cartilages, varying with age will be described separately later in this paper. Existing statistics on bone growth point out that 12 per cent of the longitudinal growth of the long bones of the lower extremity occurs from the upper femoral epiphysis. Doubt is cast on the inflexibility of these estimates as applied to this condition. The modification of the architecture of bone about the hip by infection which, in turn, is the key to hip stability is the most important factor in determining the final result. Variations will be described in the discussions dealing with each age group. Many factors influence the amount of bone remaining in the quiescent stage. These include the extent of original embolism and the type of treatment employed, especially its efficiency in preventing dislocation pressure within the joint, and further loss of bone by pressure and pathological fracture. These latter factors are under complete control of the surgeon.

The diagnosis of suppuration in the hip joint is often apparent from the occurrence of pain, muscle spasm about the hip and the physical findings of flexion and external rotation with or without abduction or adduction. When this condition occurs as part of multiple bone and joint suppuration, the local symptoms and signs are often inconspicuous and the diagnosis missed, delayed or discovered accidentally by roentgenogram. The localization of the pain is occasionally misleading depending upon the acuteness and location of the initial osseous lesions about the hip and those elsewhere. Referred pain in the thigh or knee may direct the attention of the unwary diagnostician away from the hip. In the chronic cases the patient comes to the surgeon because he has a locomotor difficulty following an acute illness.

Aspiration of the hip joint with or without arthrotomy is the only method of establishing the diagnosis in doubtful cases and is confirmatory in typical cases. It should be done early in all suspected cases. Seropurulent or frankly purulent material is obtained depending upon the duration of suppuration and the causative organism. Occasionally fluid is found which is typical of joint exudation and which is sterile on culture. This results when the bone infection borders upon the joint but

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TABLE VI — END RESULTS OF CHANGES ABOUT THE HIP RELATED TO THE INITIAL LESION OF SUPPURATIVE COXITIS

	Initial lesion					Unknown
	Synovia	Femur	Ilium	Ischium		
Dislocation	None	13	21	21	2	21
	Partial	1	7	2	0	6
	Total dislocation	3	17	7	0	24
	Totals	17	45	30	2	53
Loss of head	None	11	6	12	0	5
	Partial	3	14	15	0	17
	Total	3	21	1	0	31
	Unknown	0	1	0	0	0
Loss of neck	Total	3	1	0	2	53
	Unknown	0	45	30	2	13
	Totals	17	11	6	0	20
	None	17	23	1	0	11
Clinical shortening	Partial	0	7	1	0	0
	Total	0	2	0	0	53
	Unknown	0	45	30	2	12
	Totals	17	8	15	2	7
Shortening line to bone loss	0-2 cm	7		7	0	10
	3-4 cm	3		1	0	13
	4-6 cm	0	7	0	0	11
	6 plus	0	7	0	0	51
	Unknown	7	16	30	2	27
	Totals	17	45	22	2	3
Stability	Equal	10	17	1	0	23
	Unequal	0	4	7	0	51
	Unknown	7	24	30	2	42
	Totals	17	45	26	2	11
Motion	Stable	17	29	1	0	0
	Unstable	0	12	1	0	53
	Unknown	0	5	30	2	18
	Totals	17	45	8	0	8
Proximal femoral epiphysis	Good	5	22	8	0	27
	Poor	5	1	8	0	0
	Fused	7	16	10	0	53
	Unknown	0	4	4	2	20
Y Cartilage	Totals	17	45	8	0	17
	Closed	5	31	21	0	7
	Not closed	11	13	1	2	53
	Unknown	1	1	10	0	26
	Totals	17	45	8	2	20
	Closed	6	26	21	0	7
	Not closed	9	16	1	0	53
	Unknown	2	3	30	2	20
	Totals	17	45	30	2	53

TABLE VII.—ARTHIOTOMY AND POSTOPERATIVE TREATMENT IN SUPPURATIVE COXITIS

	Age of onset			Total
	0-2	3-7	Adolescence and adults	
Arthiotomy for drainage				
Early		45	2	47
None				45
Late		26	8	34
Unknown		70		
Total		71	10	81
Postoperative traction				
Early		17		17
None		34		
Indefinite				
Late				
Unknown		26		
Cost				
Total		71	47	118

has not involved it. Aspiration should be repeated if pus is not readily obtained when symptoms and signs suggest a pathological condition in this joint. It should be constantly borne in mind that diagnosis by aspiration is often possible many days and weeks before roentgenograms show a bone focus. Occasionally one or two aspirations will be curative but in the majority of cases, it is wiser to open the joint after aspiration has established the diagnosis, if temperature and local muscle spasm do not immediately

TABLE IX.—BACTERIOLOGICAL FINDINGS RELATED TO HIP DISLOCATION AND MOTION AT THE HIP

	Motion			
	Good	Fair	Fairly	Unknown
Microorganisms				
<i>Staphylococcus aureus</i>				
<i>β hemolytic streptococcus</i>	70			
Total			17	
Dislocation (%)	52			
Partial				
None	21	13	37	
Total	72	14	64	

TABLE VIII.—HIP STABILITY PRODUCED BY ADEQUATE DRAINAGE AND EXTENSION

	Stable	Unstable	Unknown	Total
Adequate drainage and traction				16
Indefinite treatment	11	1		12
Type of treatment unknown	29	1		30
Total	40	2	1	43

subside. In chronic cases with minor symptoms, the patient may require only traction after the diagnosis has been established by aspiration. The criterion of sufficiently prolonged traction is maintenance of joint space and position after its removal (Fig. 1).

While it usually is considered that there are no alterations to be demonstrated by roentgenograms until 7 to 14 days after onset of illness, this initial period may be prolonged to two months in those cases in which there is a small periacetabular focus. On the other hand, by the second or third day of the acute illness, there may be roentgen signs of dislocation manifest by lateral displacement of the hip from the acetabulum. This early roent

TABLE X.—LOSS OF LEG LENGTH IN SUPPURATIVE COXITIS DUE TO OSSEOUS DESTRUCTION AND DISLOCATION OCCURRING IN INFANTS AS OBSERVED MANY YEARS LATER

Patient	Age at onset	Time from onset to present observation	Class of leg length discrepancy	Loss of bone or dislocation at both or ununited acetabulum (modern value cm)
M	1½	27½	cm	cm (head and neck)
J G	mon	27½	cm	cm (head, neck and dislocation)
R E	mon	8 27½	cm	cm (head and neck)
R G	27½	27½	cm	cm (head)
D	27½	20 27½	cm	cm (head and dislocation)
A E	27½	18 27½	cm	cm (dislocation)
F B	12 27½	27½	cm	cm (head and neck)
O C	16	24 27½	cm	cm (head and dislocation)
J F	27½	20 27½	cm	cm (head and dislocation)
R D	16½	27½	cm	cm (dislocation)
D B	mon	27½	cm	cm (dislocation)
B	16	27½	cm	cm (dislocation)
A	mon	27½	cm	cm (head and dislocation)
M H	mon	27½	4 cm	4 cm (dislocation)

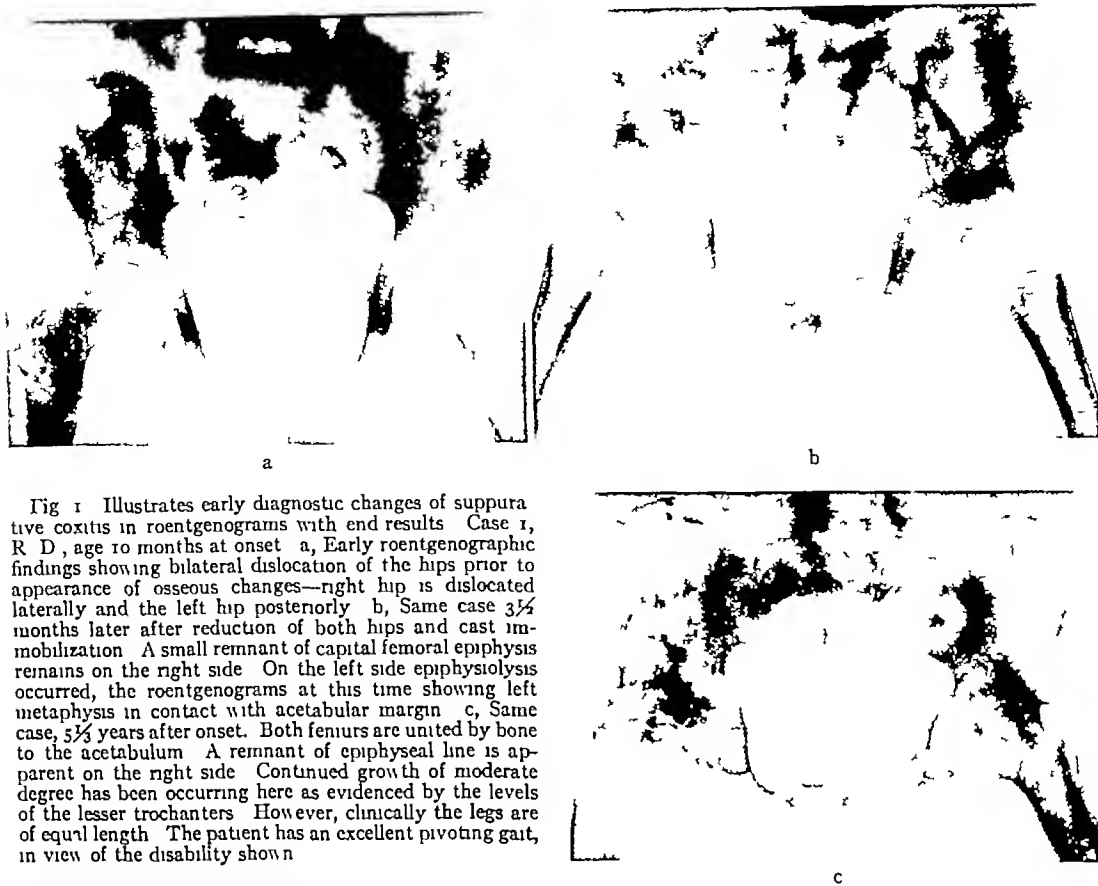


Fig 1 Illustrates early diagnostic changes of suppurative coxitis in roentgenograms with end results. Case 1, R. D., age 10 months at onset. a, Early roentgenographic findings showing bilateral dislocation of the hips prior to appearance of osseous changes—right hip is dislocated laterally and the left hip posteriorly. b, Same case 3½ months later after reduction of both hips and cast immobilization. A small remnant of capital femoral epiphysis remains on the right side. On the left side epiphysiolysis occurred, the roentgenograms at this time showing left metaphysis in contact with acetabular margin. c, Same case, 5½ years after onset. Both femurs are united by bone to the acetabulum. A remnant of epiphyseal line is apparent on the right side. Continued growth of moderate degree has been occurring here as evidenced by the levels of the lesser trochanters. However, clinically the legs are of equal length. The patient has an excellent pivoting gait, in view of the disability shown.

roentgenographic sign is the result of accumulation of suppurative products within the joint capsule. There may also be diffuse loss of joint space at a slightly later stage. Underexposed roentgenograms showing soft tissue detail may demonstrate the distended joint space, or the distended joint may be visualized by a contrast medium such as skiodan (Fig 1). So important are these early signs that roentgenograms should always be taken when the patient is first seen, even though it is far too early to demonstrate a suspected bone focus. Two general courses of this condition can be described. One, when the nature of the disease or the treatment applied does not allow joint distention to develop and dislocation does not occur. Subsequent roentgenograms may then demonstrate diffuse narrowing of the joint space which usually is still occupied by some articular cartilage. If slightly more extensive,

this alteration may be followed by surface erosion of the underlying articular bone cortex. When this latter process is completed, it is easy to understand the rapid osseous ankylosis which is then the end-result of this type (Figs 1, 2, and 6). We believe traction will prevent surface erosion of the bone cortex and allow fibrous tissue to fill in any defects in the articular cartilage. A second type can be described in which the increased intracapsular pressure produces dislocation (Figs 1 and 2). In these cases, loss of articular cartilage can be inferred only when the bony cortex is eroded, which is then seen in the roentgenogram (Figs 1 and 2). The loss of bone and shortening due to it are dependent upon the extent of bone involved by infection and the efficacy of traction employed in treatment (Figs 1, 2, and 6). Late shortening may be the result of closure of the upper femoral epi-

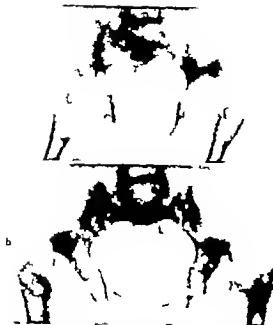


Fig. 1. Bone loss in streptococcus infection of the upper femur involving the hip joint. Illustrations of sequestration of the femoral head. Case 1, J. D., age 23 months at onset. a, Roentgenogram 5 months after onset showing bilateral dislocation of the hips, extensive osteomyelitis of left upper femur and right ilium. Epiphyseolysis has occurred on the left side, and partial destruction of the distal femoral epiphysis has occurred on the right side. This massive bone involvement by β hemolytic streptococci demonstrates that, on occasion, just as extensive bone involvement can occur with this organism as with the staphylococcus. b, End-result of same case, 9 years later. Both hips have about two-thirds of normal range of active motion. The right hip is stable in an acetabulum just below the normal one. The left hip is unstable but significant portion of femoral neck remains.

physis. Unless dislocation is present the amount of shortening is usually negligible (Table 1, end-results). In both types, bone alterations as seen in roentgenograms are similar but less marked than changes found in osteomyelitis of the long bones.

The causative organism *per se* does not condition the amount of bone destruction (Fig. 2). Extensive osteomyelitis with gross bone loss may result from either β -hemolytic streptococcus or from staphylococcus infection but usually the extent of bone involvement is less and primary synovial infection more common when streptococci especially the β -hemolytic variety are the causative organisms. Joint sequestra of variable size up to the whole



Fig. 2. Case 2, A. W., age 5 at onset, staphylococcus hemolyticus infection. a, Roentgenogram showing massive osteomyelitis of the upper right femur with sequestra of the head. This head, as later removed, and the remaining portion of the neck, as placed in the acetabulum. b, Roentgenogram taken 9 months later showing stable hip. A subsequent clinical examination made one month still later shows stable hip and half the normal range of active motion.

femoral head (epiphyseolysis) may result and unless removed become the cause of long continued drainage (Fig. 3). Joint sequestra have previously been described. The diagnosis is more difficult and the indications for treatment less clear-cut in the patient with chronic hip joint disease. Suppuration within the hip is causative of a certain amount of chronic hip joint disease. There is no typical history in these cases, but often the onset of the hip disorder dates from an acute illness. Their complaints are the usual ones associated with disease of the lower extremities: inability to walk or recurrent pain after walking; shortness of the extremity and difficulty in sitting. When examined a draining sinus may or may



Fig 4 Case 4, R P, age 7 at onset, β hemolytic streptococcus infection a, left, Roentgenogram showing necrotic right femoral head, and osteomyelitis of the right femoral neck 5 weeks after onset. Patient was treated by cast immobilization and arthrotomy b, End result 1 year after onset showing ankylosed hip with healing of osteomyelitis process. Distortion and collapse of this femoral head have occurred during transformation in the presence of infection

not be present (Fig 5). The patient is often unaware of the loss of hip joint motion. Aspiration of the joint in these chronic cases usually does not yield copious fluid but is informative if cultures for bacteria are made. Roentgenograms of the chronic cases show bone destruction (Figs 2, 3, and 4), and the joint space is usually gone or modified. In extreme cases the "wandering acetabulum" is seen (Fig 6). Roentgenograms may not be diagnostic, so that arthrotomy or joint puncture is then the only way of establishing a diagnosis (Fig 7).

When bone involvement is not apparent in early stages of this disease, a study of serial roentgenograms will usually show changes (90 per cent of 24 acute cases in this series). Many of these cases would have been termed "synovial infections" if they had not been followed by serial roentgenograms. Small infectious bone foci require weeks and occasionally months to become apparent. It is interesting to note that all acute suppurative hips (7 cases) caused by the β -hemolytic streptococcus were associated with some degree of bone suppuration. The extent of bone

suppuration and bone necrosis was definitely less in this group of cases than in those in which the staphylococcus was the causative organism. If drainage of the hip is established under the proper indications, the location of the initial lesion has prognostic significance. If the bone lesion is in the neck of the femur, necrosis of all or part of the femoral head with or without pathologic fracture of the neck is seen. This latter is often prevented by assiduous application of traction (Fig 8). Statistics relating to end-results, tabulated in terms of the initial location of the suppurative focus are found in Table VI. An inspection of these end-results shows that dislocation occurred most often when there was loss of bone from the femur. Clinical shortening of the more advanced degrees, shortening due to bone loss, hip joint instability, and destruction of the epiphyseal cartilages at the upper femur and at the junction of the ilium, ischium, and pubis (y-cartilage) occurred more frequently and in greater percentage when the femur was involved. The extent of the osteomyelitis focus when it occurs in the ilium is illustrated in Figure 9, showing such data for



Fig. 5. Case 5, O. D. age 9 years at time of roentgenogram. This illustrates joint sequestrum of portion of the femoral head. This sequestrum was removed by enlarging an adductor strain which had persisted since the original infection 7 years previously. Healing promptly occurred.



Fig. 6. Case 6, M. C. 6 years after onset of infection (then aged 37 years). An antral suppurative hip abscess had resulted. The joint space is narrowed and the normal all of the articular surfaces has laminated (X-ray pelvis). On examination patient had right flexion contracture at 90 degrees of active flexion.

35 representative cases. The special causes and prevention of these conditions will be discussed in a later section of this paper.

Initial lesions in the femoral head were not observed in our series, but they are said to occur. Roentgenograms illustrative of septic embolism through the vessels of the ligamentum teres are reproduced in Wilensky's book. When an osteomyelitis focus is in the bones of the pelvis, the joint is spared more often than

when the focus is in the neck or upper portion of the femur. Occasionally, however, a bone focus may become established within the femoral neck without involving the hip joint. Tables II and III give the distribution of the foci of suppuration causing hip joint involvement. The point of original involvement can be determined only by inspection of roentgenograms at an early stage in the modification of the bone. Later it is impossible to be certain of the exact location of the first suppurative focus due to further bone destruction and to changes produced by pressure and dislocation.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis of hip joint involvement in the acute stage is usually easy when the signs and symptoms are clear-cut. In the cases with insidious onset and in those that have long since healed with deformity the differential diagnosis is not always apparent. The following conditions have to be considered: Tuberculosis, Legg-Calvé-Perthes disease, solitary chronic nonspecific arthritis, old slipped upper femoral epiphysis, osteochondritis dissecans of the hip, osteogenic and chondrosarcoma, old congenital dislocation of the hip, aseptic necrosis of the femoral head due to trauma with or without dislocation.



Fig. 7. Case 7, L. W. aged 3 years (onset). The roentgenogram shows an osteomyelitic lesion in the stream of the joint space. An arthrodium was attempted under the erroneous diagnosis of tuberculosis of the hip. Disastrous results in favor of pyogenic cocci involvement of all surfaces of femoral head, diffuse lesion in ilium consisting of areas of osteolysis and sclerosis, narrowing of the joint space and perforated new bone.



Fig 8 Case 8 Preservation of the femoral neck by traction in the presence of embolism of this structure a, Three weeks after onset showing bone destruction in the upper two-thirds of the femoral neck. Arthrotomy had been performed following joint aspiration two weeks previously, b, 4 months later after removal of the sequestered upper third of the femoral head indicated by arrows in a

Note the new bone bridging the neck defect and filling in the space left by removing the femoral head sequestrum, c, 7 1/2 years after the acute disease. Although the hip is solidly ankylosed and weight bearing trabeculae are evident, there has been no loss in leg length because fracture was prevented in the acute stage by the application of traction

metastatic tumors, syphilitic bone involvement and rarer conditions such as hemophilia, idiopathic subperiosteal changes in the newborn, xanthomatosis, fibrocystic disease, neurofibromatosis with bone involvement, caisson disease, echinococcus cysts, and bone islands

Roentgenograms in tuberculosis of the hip will often suggest the diagnosis since early destruction is marginal or in the metaphysis and unassociated with sclerosis. In adolescents and adults, "kissing sequestra" may be present. The joint space is usually preserved longer in tuberculosis. The Mantoux and other tuberculin reactions are usually positive. The only means of establishing the diagnosis in some cases rests upon tissue examinations and the results of bacterial culture and animal inoculation when the joint is opened (Fig 7)

The end-results in Legg-Calvé-Perthes disease are typical in roentgenograms. The deformity consists of widening of the femoral neck, flattening of the head with minimal changes in the acetabulum. The end-results of slipped femoral epiphysis are likewise typical, with coxa vara and external rotation of

the distal fragment. In chronic nonspecific arthritis there is usually loss of joint space without deformity, to be followed later by marginal hypertrophic changes and sclerosis in the weight-bearing portions. There is often multiple joint involvement in this condition, but the hip joint alone may be affected. In osteochondritis dissecans the point of origin in the articular cortex from which the sequestrum has separated may be identified.

Osteomyelitis of the ilium with or without hip joint involvement has been erroneously diagnosed as osteogenic sarcoma of that bone in chronic cases that subsequently came under our care. One of our cases was referred under this diagnosis, having received extensive roentgen therapy elsewhere. A biopsy with cultures for bacteria will aid in establishing the diagnosis. In aseptic necrosis of the femoral head, trauma with fracture of the neck or dislocation has usually preceded the condition, but in some instances such a history is lacking. Old congenital dislocations present the typical history of disability beginning the second year of life with or without subsequent treatment.

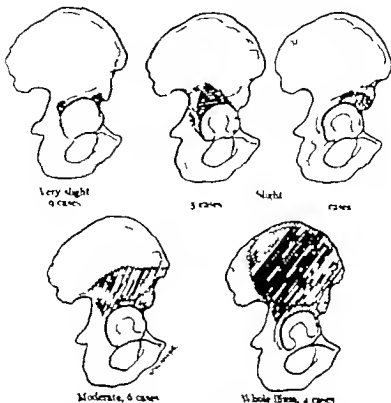


Fig. 9. Sketch representing relative anatomic locations of forms of osteomyelitis in 35 representative cases in which the osteomyelitis is the cause as responsible for suppurative arthritis.

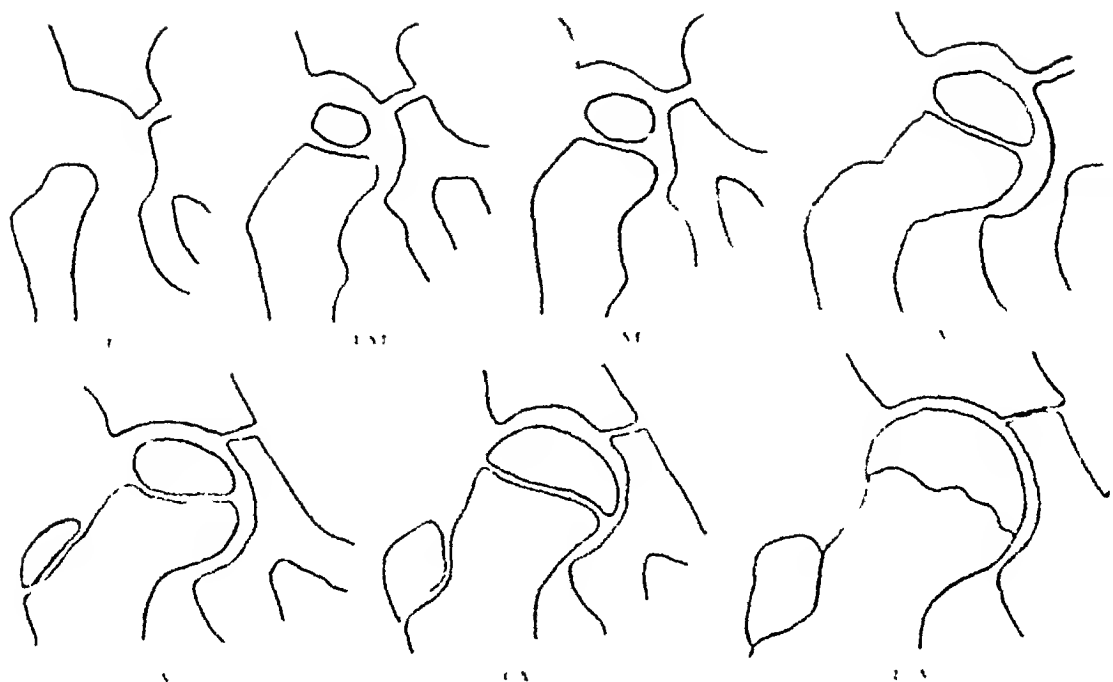


Fig. 10. Case C. B. C. aged 8 years at onset. Illustration of stable hip joint due to fragment of the head or neck remaining. Roentgenogram taken 8 years later (age 14 years). This patient chief disability was due to shortening on the involved side. Motion in the involved hip as normal except adduction limitation.

The appearance of the femoral head depends upon the age of the patient when treatment was first applied and the success thereof. The rarer conditions here enumerated are either characteristic in the roentgenogram or are definitely diagnosed as a result of biopsy.

TREATMENT OF ACUTE STAGE WITH END-RESULTS

After a review of these cases, one conclusion is apparent: the majority of complications resulting from this disease are avoidable provided an early diagnosis is made and prompt and efficient treatment is applied. An unsatisfactory result will be obtained only under exceptional circumstances: 1. the very young when extensive embolism of the upper femoral has occurred and when there is bilateral hip joint involvement. Results in the latter are will be discussed in a special section.



END-RESULTS OF SUPPURATIVE ARTHRITIS OF THE HIP IN PATIENTS UP TO THE AGE OF THREE YEARS

In this age group particularly during the first year and a half of life the symptoms are not clear-cut and the opportunity for the orthopedic surgeon to see the patient early and perform an accurate examination seldom occurs. The general physician and surgeon often does not realize that the abscess about the hip is the result of suppuration within a joint the components of which are almost or entirely cartilaginous. If several days have elapsed before drainage is instituted the cartilaginous head and neck have been destroyed by suppuration, and a pathological dislocation results even though traction is employed. Traction can be employed in the acute and recovery stages when the presence of a cartilaginous epiphyseal center for the head is not known but is suspected from the clinical examination. Eleven of the cases upon which we have end result data fall into a restricted group in which suppuration occurred in the first few weeks of life and 7 of these cases presented dislocation of the hip prior to reconstruction. The measure used in reconstruction of these hips will be discussed in a later section.

In such cases if pathological dislocation is present, the epiphyseal line has usually also been destroyed by suppuration. Since 12 per cent of the growth of the long bones of the lower extremity in a normal person comes from this epiphysis, appreciable shortening should theoretically be observed years later. Fourteen cases of this whole group (Table V) were seen again from $3\frac{1}{4}$ to 14 years after the epiphyseal line was destroyed by suppuration. When loss of leg length due to bone loss and that due to dislocation were separately measured on roentgenograms, the total loss due to dislocation was practically identical with the difference in clinical leg length measurements in all save 3 cases. Since the epiphyseal line was destroyed in all these cases, compensatory overgrowth of other epiphyses in the other lower extremity must be postulated.

The end-results in terms of bone loss and stability correlated with the initial lesion are given in Table VI. The effects of the loss of

femoral head and neck from suppuration and its effect upon dislocation are seen most often in the youngest age group. In this age group as well as in the following older group (onset before 13 years) shortening observed years later is due to loss of bone and to dislocation rather than to significant lack of growth of the involved femur (Table V).

END-RESULTS OF SUPPURATIVE ARTHRITIS OF THE HIP IN PATIENTS FOUR TO TWENTY YEARS OF AGE

Reference to Figure 12 shows that during this age period the separate epiphyseal centers about the hip reach their maximum size before uniting with the diaphysis. Symptoms and signs during the period can usually be elicited with accuracy so that diagnosis is not difficult. Eleven of the 69 cases in this group were seen in the acute stage. The infection originated in bone in all the acute cases and in 39 of 45 hips of the entire group in which this factor could be determined. End-results are given in Tables VI, VIII and IX. It is noteworthy that half the whole series had an onset during childhood and likewise the greatest loss of bone occurred since the incidence of osteomyelitis is greater here and most of the neglected cases, sent to us later for reconstructive procedures fell into this group. Fusion to the pelvis occurred when bone was lost and dislocation was less frequent. There was a greater incidence of hips with restricted motion present in this group due to this and other factors. Closure of the proximal femoral epiphysis and the γ -cartilage at the hip occurred in about two-thirds of the cases as judged from inspection of check-up roentgenograms from which these end results were obtained.

As is the general trend in these cases, the infection occurred in the bone about the hip prior to joint involvement since in 39 of 45 cases the original point of infection could be accurately determined from inspection of serial roentgenograms. The origin of infection was about equally divided between the skin and the upper respiratory tract, in line with the incidence of ear and respiratory infections in children. Only two-fifths (6 of 16 cases), in which the infecting organism was known were caused by the β -hemolytic streptococcus.

Arthrotomy for drainage was carried out early in most of the cases (45 of 68 cases), but the beneficial effects of such a procedure were nullified to some extent by the fact that traction had not been used in half these cases. These latter cases were, at the same time, the ones that presented the major reconstructive problems. In the 23 cases in which traction was not employed or was used late in the acute disease, there was the greatest incidence of ankylosis in malposition and loss of leg length due to bone loss and epiphysiolysis. This was particularly true in the younger patients of this group. In patients beyond 10 years of age there was very little bone loss even when traction was not employed unless the original embolism was massive. The case illustrated in Figure 10 in which the hip remained stable due to neck fragments that remained falls into this age group. Traction was the determining factor in these cases and in others in which such a result was obtained.

The median value for the amount of shortening in this age group was 3 centimeters. In only 10 per cent of the cases were we unable to account for all the shortening by dislocation, bone deformity about the hip, or actual bone loss—illustrating again the minor significance of destruction of the capital femoral epiphysis. Reconstructive measures to combat this shortening will be discussed later.

Spontaneous ankylosis of the involved hip was common in this group (21 of 78 hips). These were largely patients who had been treated in casts or allowed to remain in bed without support to the limb. Gait and function were good if position of the limb was satisfactory, but this result was achieved by osteotomy if malposition had resulted (see section on reconstruction). In 11 instances the head, usually *in toto*, was removed as a sequestrum. In 3 patients seen by us at a later date, drainage had continued for 2, 6, and 8 years, respectively. Drainage promptly ceased upon removal of the necrotic head.

END-RESULTS OF SUPPURATIVE ARTHRITIS OF THE HIP IN PATIENTS OVER THIRTEEN YEARS AT ONSET

Even in the younger patients of this age group, the epiphyseal centers about the hip

have reached their maximum size, but those at the upper femur do not unite with the shaft until the age of 16 in girls and 18 or 20 in boys. Thirteen of the 43 cases in this group were seen in the acute stage. The infection originated in bone in 4 of 10 cases in which the initial focus could be determined in follow-up roentgenograms. The most diverse origin of the infection was encountered in this group: puerperal and other septicemias, gonococcus infection, infection following operative reduction of dislocation of this joint, as well as the usual infections that proceed from the skin and upper respiratory tract. The causative organism, when known, was usually found to be the *Staphylococcus aureus* (16 of 19 cases). Such a finding may be explained by either the large number (28 cases) for which this information was not available or the less incidence of upper respiratory infections in this older age group.

Arthrotomy was performed in only 7 of the 13 acute cases and traction employed with open drainage in only 4 cases. In these acute cases, spontaneous dislocation was encountered but once and this directly following removal of support (cast) in a relatively acute stage of the disease. In general, in this group, the extreme of bone involvement was less and loss of leg length due to either bone destruction or dislocation was minimal (median value being 0 cm) when the whole group was viewed. However, such findings do not lessen the indications for traction as the amount of bone involvement is still a factor that cannot be evaluated until visualized by roentgenograms which always lag 7 to 14 days behind the actual changes. In 2 cases of the group, prompt and continuous application of traction undoubtedly prevented pathological fracture and subsequent shortening due to bone loss (Fig 8), while in other cases traction indifferently applied resulted in fracture.

When this group of 47 hips is analyzed, dislocation was the end-result in 7 instances, all these remained mobile except one case. The most common outcome was that of preservation of motion in the primary acetabulum (32 of 47 hips). All of these, with but 2 exceptions, had greater than 50 per cent active motion at the involved hip. In this group of

adults, pain was a noticeable and prominent complaint in 10 of the 32 hips (see section on reconstruction). This is in contrast to the movable joints in the two younger groups of patients in whom a painless mobile and stable joint was a frequent outcome. It should be pointed out that these end results from suppuration in children carry them only into the third decade of life. Undoubtedly presenile osteoarthritis accompanied by pain will later result in a certain number. In defense of the mobile joint it should be pointed out that they will have enjoyed 20 years of painless and unrestricted locomotion. Spontaneous fusion occurred in the primary acetabulum in 8 of the whole series. Prolonged cast immobilization was the determining factor in the last mentioned group, and indeed appeared to be the only factor in the entire group that favored the certain outcome of fusion. Motion developed in many patients after cast immobilization as well as after traction. Conversely, ankylosis did not occur in a single case when traction was employed.

Since bone loss due to suppuration was not commonly seen in this group, disability due to shortening was negligible, there being only one third of the group presenting shortening as an end result (7 of 47 hips). The median value for the entire group was 0 centimeter and for those showing shortening was 2 centimeters. The 5 cases in which gross bone loss occurred were all associated with massive or appreciable osteomyelitis of the upper femur (Table VI).

Due to some measures to the adult structure of the bone and the minimum amount of cartilage present within the joint, sequestration of the entire femoral head was not observed in this group except in 4 instances in which it followed pathological fracture through the femoral neck in instances of massive osteomyelitis of this region. In 9 additional cases, the superior portion of the femoral head (usually the superior third) became detached as a joint sequestrum. In these cases, study of serial roentgenograms suggested that this outcome was the result of embolism of the corresponding portion of the underlying neck and in 2 instances was associated with the capsular tears of previous hip joint dislocation. Re-

moval of this sequestrum resulted in prompt cessation of drainage except in cases of massive osteomyelitis.

CHEMOTHERAPEUTICS IN SUPPURATIVE HIP JOINT DISEASE PREVENTION OF JOINT SUPPURATION

During the years required to compile the data for this report to follow up the patients and to analyze the end results, the sulfonamide group of drugs came into clinical use. Their value has now been determined for almost every bacterial infection. While the end-results in this report are from cases in which the sulfonamide drugs were not used in the acute stage, experience with several acute cases in which patients were treated in the acute stage with the sulfonamides, chiefly sulfathiazole, demonstrates that these drugs do not alter the essential clinical course of joint suppuration. Their chief value appears to be in limiting suppuration. As a rule, fewer cases require arthrotomy and more can be carried over the acute stage by repeated joint aspiration. It also appears that fewer primary and secondary operations are required upon osseous foci of suppuration in patients who have received sulfonamides, particularly in children. The essential osseous picture following suppuration is not changed but modified in the direction of lessened virulence (Fig 13).

The use of these drugs in the acute stage makes early bacteriologic diagnosis by blood cultures and by joint aspiration necessary in order to select the specific drug, although sulfathiazole and sulfadiazine appear to be sufficiently active against all pyogenic microorganisms. It has been demonstrated that the concentration of sulfathiazole is two-thirds to three-fourths of that present in the blood in joints the seat of effusion (and presumably also in joints the seat of suppuration). Since suppurative joint disease is often a complication of neighboring osteomyelitis, we can anticipate fewer instances of suppuration within the joints in the future if vigorous chemotherapy is employed at the earliest moment. While the record is not yet clear as to the exact value of these drugs in limiting osseous suppuration, they have definite value in less-

ening the severity and duration of the blood stream infection and have a favorable effect upon temperature in septicemia and osteomyelitis. Surgical attack upon the bones at an appropriate time is still important, but with the use of the sulfonamides, greater conservatism in handling the osseous foci is possible. The surgeon can await the evidence of localization in roentgenograms with less danger of joint and other complications when these drugs are employed. While the results of bacterial culture of the blood and joint aspirations are awaited, chemotherapy can be tentatively started, sulfathiazole or sulfadiazine being used. Osseous and suppurative joint complications from the upper respiratory tract should receive sulfanilamide (hemolytic streptococcus) while those complicating skin infections should receive sulfathiazole (staphylococcus) pending receipt of data from the laboratory.

Evidence is accumulating that the metastatic effects of suppuration from upper respiratory origin (including middle ear disease) and from the primary sites of invasion of staphylococci are less in incidence and severity under the influence of chemotherapy. Many years of accurate clinical observation will be necessary to show the exact rôle these drugs have in the prevention of osseous and joint complications. The evidence to date indicates that the earliest possible bacteriologic diagnosis should be established both in the preceding conditions that give rise to bone and joint suppuration and in osseous complications themselves. The application of chemotherapy, though, should not minimize the surgical and mechanical principles stressed in the previous sections of this paper.

SUMMARY AND CONCLUSIONS

1 In a study of the end-results of suppuration in 147 hip joints in 132 patients of all ages, a relatively benign course of the infection is observed under the following conditions (a) in the very young (beneath the age of 2 or 3 years) and in older persons (beyond the age of 15 or 16 years), in whom bone involvement is often restricted in extent, (b) in other age groups the bone lesion being small or non-existent, (c) in cases in which early

arthrotomy and prolonged and continuous extension is employed

2 The greatest disability and prolonged course of the disorder appeared in patients whose disease had followed massive osteomyelitis. Joint sequestra, ankylosis, and loss of bone from the femur are commonly seen under these circumstances

3 The end-result of a movable hip stabilized in the primary acetabulum appears to be more desirable than an ankylosed hip unless such motion is accompanied by pain. In juveniles, such a movable hip may function for many years before pain disables the patient. Even when epiphysiolysis and loss of portions of the femoral head and neck occur, many cases come to this end-result if favored by continuous extension and prolonged recumbency. Serial roentgenograms are a necessity in applying treatment, especially after the bone lesion is visualized

4 The variety of causative organism appears to effect the outcome only in so far as the hemolytic streptococcus is usually associated with minimal bone destruction and the hemolytic staphylococcus with moderate or extensive osteomyelitis

5 The factor of sex has no influence on the outcome

6 The segregation of cases of suppurative arthritis of the hip according to the age groups suggested (a) the very young (inclusive to 3 years), (b) children (4 to 12 years, inclusive), (c) adolescents and adults (more than 13 years of age), is warranted upon the basis of a different outcome in each group. This outcome is in turn also conditioned by natural factors which are uncontrollable, such as the severity and extent of infection, and by the type and duration of treatment applied

7 Loss of leg length is chiefly due to dislocation of the hip and bone loss. The former is commonly seen and is the only factor producing shortening in the very young and in adults unless pathological fracture occurs in bones involved by extensive osteomyelitis

8 The specific influence of the above factors is illustrated by the histories and roentgenograms of cases. The clinical course and deformities observed fall into definite groups determined largely by the amount and

location of the destruction and the treatment applied.

9. Early diagnosis by joint aspiration early in the course of the disease is possible when roentgenograms fail to show the presence and extent of bone changes.

10. Chemotherapy with either sulfathiazole sulfanilamide or sulfadiazine should begin immediately following early bacteriologic diagnosis, both in acute osseous bone and joint suppuration and in the conditions which are known to serve as a primary focus for such infections. Presumptive chemotherapy may begin before laboratory data are available if the history is carefully analyzed. Penicillin although promising, has yet to be applied to this group of cases.

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ORIGIN OF OVARIAN ADHESIONS FROM ORGANIZED LIQUOR FOLLICULI IN THE RHESUS MONKEY

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IN the course of numerous laparotomies performed on the rhesus monkey (*Macaca mulatta*) at the Carnegie Laboratory of Embryology in Baltimore, the writer every now and then observed (Hartman, 1937) an ovary that was connected with the omentum or with the tubal fimbriae by one or more strands of tissue, mostly thread-like but ranging up to 1 millimeter or more in diameter. A similar observation by the writer had been made many years previously in the opossum since on one occasion a very fresh and blood-red strand was seen to arise from the stigma of a recently ruptured follicle and peripherally was already attached to the fimbriae, it appeared entirely possible that such adhesions consisted of organized strands of drawn out liquor folliculi. Special attention, therefore, of over two dozen cases has been analyzed. The series covers early stages in the genesis of the adhesions as well as their persistence over a period of several months.

In order to understand how the liquor folliculi issuing from an open rupture point in the early development of the corpus luteum can form a scaffolding on which connective tissue and blood vessels may grow to form a more or less permanent structure one must be familiar with some of the characteristics of the liquor folliculi of the freshly discharged follicle.

CHARACTERISTICS OF THE LIQUOR FOLLICULI

A. Robinson (1918) was the first to describe the succession of three phases in the secretion of fluid secreted into the cavity of the graafian follicle. His description has since been corroborated and the phases have been more accurately fitted into those events of the sexual cycle grouped around the process of ovulation.

Liquor folliculi of the first order is secreted during the phase of slow growth of the follicle. It is dense and somewhat viscous and comes to surround the ovum and its corona radiata. During the preovulatory spurt of growth of the graafian follicle there is secreted a much thinner fluid relatively free of coagulable material, which is deposited at the free surface of the granulosa membrane. It is this liquor folliculi of the second order to which the rapid preovulatory growth of the follicle is due. This fluid is the portion that issues with a spurt at ovulation or when the ripe follicle is pricked. Its function is to free the viscid mass containing the ovum at the center. It is the writer's idea that the liquor folliculi of the first order plays an important rôle in the extrusion of the ovum. It functions presumably in forming a pliable mass on which the powerful cilia of the enveloping fimbriae can get hold and thus drag the imprisoned ovum out, as witnessed for example by the lines of tension in a section of a freshly ruptured follicle (Fig. 12 in Hartman, 1939).

After the collapse of the follicle and even while its wall is metamorphosing into the corpus luteum, secretion continues and liquor folliculi of the third order is produced. In the writer's view this is the material which forms the skeleton on which the adhesions about to be described develop. It is exceedingly viscous and in the fresh state very tenacious, so that by touching a cotton swab to the stigma of a fresh corpus luteum the material may, in a favorable case, be made to adhere and may then be pulled out into a strand 1 or 2 inches long, and this may be repeated several times on the same specimen, though the succeeding strands are progressively shorter. Very often this gelatinous liquor folliculi of the third order may be seen forming the center of the plug closing the stigma, the granulosa or lutein tissue forming a rim around it. The swelling of the corpus luteum is due partly to

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the accumulation of the liquor folliculi of the third order in the lumen of the gland.

Such tough liquor folliculi may arise in spontaneously formed atretic follicles in both the monkey and the opossum. It is especially marked in atretic follicles produced by over stimulation by gonadotropes (Hartman, 1938, 1943) when the antrum becomes filled with coagulable material so firm that after fixation the contents of the follicle may be lifted out in a solid mass.

EARLY STAGE OF THE ADHESIONS

The records contain 4 cases in which adhesions were observed in the making—strands of blood red hyaline substance still imperfectly organized and vascularized, extending out from the ovarian stigma.

Monkey No. 645 ovulated between day 8 and day 9 of the December 1938 cycle, ovulation as checked by laparotomy on the following day. Expecting an early ovulation also in the January 1939 cycle, the female was mated on day 8 and laparotomized on day 5. The prediction proved wrong for ovulation had just taken place, a well preserved unfertilized egg being recovered (C 634). The stigma consisted of a mass of red-orange granular tissue surrounding a hyaline strand continuous with similar material within the freshly ruptured follicle. Nothing is stated in notes as to distal attachment of strand.

Monkey No. 466 also furnished an unfertilized ovum (C 583). From the blood-red stigma measuring by 3 millimeters (Figs. 1 and 2) the granular herniated out on a strand about 4 millimeters long and 0.5 millimeter in diameter and from the tip of this finer thread proceeded to the edge of the fimbriae. The basal portion contained granular cells. This specimen regarded as the very beginning of the new type of adhesion here described. It might be designated as Exhibit A in evidence favoring the theory here advocated.

Monkey N. 395 received a course of treatment with gonadogen (pregnant mare serum extract, L. Johnson) from February 1, 1937 (day 7 of the cycle) to February 7. On February 9 the ovary as removed. From fresh corpus luteum, estimated to be 1 day old, delicate adhesion extended to fimbria.

Monkey N. 46 ovulation as diagnosed by palpation on October 2, 1937, day 9 (or ?) of the cycle. At laparotomy 2 days later adhesions were seen on the right (actu.) ovary, one very delicate thread running out from the small new stigma, the other, thicker one, millimeter in thickness, from a papilla marking the site of corpus albicans. On October 4 an day embryo was removed together with the ovary. Only one adhesion remained, the older and established one, the other having been removed.

CONTINUITY OF ADHESIONS WITH CORPORA ALBICANTIA

The continuity of the strands with the corpus luteum in the 4 cases just described seems clear enough, but if the theory here proposed is to be proved correct it is necessary to demonstrate continuity of old, well organized adhesions with corpora albicantia. This has been done. Besides, in a number of cases luteal cells identical with those in the corpora albicantia have been traced into the basal portion of the adhering tissue.

It should be stated, however, at the outset that in 4 instances in which this point was investigated the adhesions are traceable back merely to the generalized ovarian stroma. This is not surprising inasmuch as Corner (1941) has shown that within about 6 months the monkey corpus luteum disappears without leaving a trace. Thus, for example, in Monkey No. 334 the last ovulation had occurred 10 days prior to the removal of the ovary with the adhesion to the omentum. This period then represents the minimum age of this adhesion. In the opossum in which I have observed similar adhesions the corpus luteum remains recognizable for only 3 months (Maruneau-Estève, 1942).

Parenthetically it might be pointed out that in the 10 cases in which the adhesions are traceable to recognizable remains of corpora lutea these are never of the peculiar type discovered by Corner (3) and called corpora aberrantia by him, but are always the corpora albicantia as we know them from human ovaries. A few examples may be given.

Monkey N. 324 furnished the most bizarre ovaries yet encountered (Figs. 3 and 4). One would be inclined to reject this case as one not pertinent to the issue were it not for the fact that at least 2 of the many adhering strands are directly traceable to corpora albicantia (Fig. 5) that remains of luteal cells are to be seen in them, and that before the ovaries were removed the corpora lutea twice were seen to herniate excessively. The following procedure is necessary for proper evaluation of the case.

The animal as received on November 20, 1931, showed fairly normal menstrual cycles from the time of her arrival, with probable ovulations. Ovulation as diagnosed March 20, 1935 (day 1) Three days later fragmenting ovum (C 534) as we bled out terms via the cervix, by means of a postmenstrual syringe the needle of which was thrust through the abdominal and uterine walls. This was repeated on

April 25, without, however, this time recovering an ovum. On December 31 the uterus was flushed during laparotomy, that is, with the abdomen open, and left ovary was removed because of numerous adhesions.

The current corpus luteum had herniated out and spread toward the hilum. On December 14, 1935, the uterus was again flushed through and 2 days later an exploratory laparotomy was done. On this occasion the 3 needle holes in the uterus were still visible and from 2 of them delicate adhesions emanated. The ovary showed nothing unusual, being entirely free of adhesions. On January 18, 1936, a defective 11 day embryo was removed by hysterotomy. The accompanying ovary showed again a very large, much herniated corpus luteum. This surviving ovary was finally removed on March 17 and for the third time in this animal a herniated corpus luteum was found, this time markedly everted, at least nine-tenths of the volume being "outside" the ovary proper (Corner, 1943).

To summarize this case, we find associated with a marked tendency of the corpus luteum to herniation (as seen in 3 laparotomies) the most excessively developed system of adhesions, several of which are traceable to corpora albicantia. The adhesions are hardly referable to trauma incident to prior puncture of the uterus with a hypodermic, for this was confined strictly to the uterus and the surviving ovary, removed later, had no adhesions.

Several other cases out of the 11 in which the continuity of the adhesion with luteal tissue was established, may now be described.

No 460, not previously operated upon, was laparotomized for the purpose of removing a 23 day embryo (C 597). A fine thread of tissue was seen attached to the current corpus luteum.

No 611 furnished the ovary shown in Figure 7 on February 3, 1941. The tag of tissue protruding from the ovary was connected with an old corpus albicans. The ovary contained the current corpus luteum (of which the pale stigma is seen to the left of the process in the illustration), a corpus albicans of the previous cycle and the one in contact with the adhesion (Fig 8). The finely vacuolated luteal cells are spread out to the base of the adhesion but do not enter it. On the preceding October 20 a 12 day embryo (C 654) had been removed by hysterotomy. At this time there was no adhesion to either ovary, the stigma was also pale and anemic as on the later occasion. Whereas No 324 already discussed showed a tendency to herniation of the luteal tissue No 611 had nonprotruding pale stigmas (2 observations), nevertheless this animal also developed an adhesion.

No 660. In the case of this monkey the graafian follicle broke under the palpating finger on October 23, 1930 (day 11) and a laparotomy was performed 6



Figs 1 and 2 Surface view and cut surface of ovary halved, showing adhesion continuous with the lumen of the corpus luteum. Monkey No 466. Photographed fresh $\times 32$.

days later. A corpus luteum had formed, there was no adhesion. On December 20 the animal was hysterectomized and the remaining ovary removed (11 day ovum No C 662 was recovered). Figure 9 shows the fresh cut surface of the ovary, with current corpus luteum (pale) and that of the preceding cycle (dark), from which stems an adhesion. This contained luteal cells comparable with those of the adjoining corpus albicans (Figs 10 to 12).

SIZE, NUMBER, AND PERSISTENCE OF THE ADHESIONS

As already appears from the data thus far presented the ovarian adhesions range in size from delicate threads to strong bands several millimeters in diameter. Eight entries in the records give about 1 millimeter as the thickness, and 8 others are designated in the notes as fine or delicate, a half dozen were described as thick or coarse and of these No 324 represents the extreme both as to number and as to coarseness. Eight cases had 2 adhesions each, mostly of different thickness, and in all but 1 they arose from different points on the ovarian surface. In several cases it could be shown that the members of the pair arose from corpora albicantia of different ages. No 677, however, was unique. 2 strands arose from the same point on ovary and inserted at separate points on omentum. Here the point of origin could not be related to a corpus albicans.

That the adhesions persist for months is clear from successive direct observations as well as other evidence, as for example the age of the corpus albicans (Corner, 1942). On the other hand, in 2 cases the strands were ephemeral. That of Monkey No 462 was a delicate



Figs. 3 and 4. External surfaces of ovary of Monkey No. 34 showing the masses of adhesions. Photographed fresh. $\times 3.2$. (Section shown in Fig. 5)

thread running from the stigma of a fresh corpus luteum seen at laparotomy on October 14, 1937. This was no longer present 8 days later whereas another older strand 1 millimeter in thickness had persisted. Observations on the second case, No. 659, are especially suggestive. On October 25, 1939, a laparotomy was performed to check a diagnosis of ovulation and on this occasion an adhesion was seen and a sketch of it made. Ten days later only the stump of the adhesion remained in the form of a coarse papilla (Fig. 13). Since papillae are sometimes seen on ovaries (as for example that shown in Fig. 14) the case just cited might offer the explanation as to the genesis of some of them and also suggest that established adhesions may also break and be largely resorbed.

Exact ages of a number of adhesions are known because the ages of the corpora lutea to which they are attached are known. Those found in Nos. 282, 611, and 660 were 11 or 12 days old; that of No. 460 still a fine thread, 23 days; that of No. 680, 60 days. No. 401 had no adhesion on October 27, 1936, but on November 24 there was an adhesion 10 days old. In the case of No. 457 a delicate thread was seen between ovary and umbilic and sketched on February 7, 1937. It was still there on March 29. The fresh adhesion in No. 677, December 7, 1939, was removed with ovary 3 months later. The very delicate thread



Fig. 5. Section of the ovary of Monkey No. 34 shown in surface view in Figures 3 and 4. The continuity of the adhesions with corpus albicans is seen. $\times 3$.

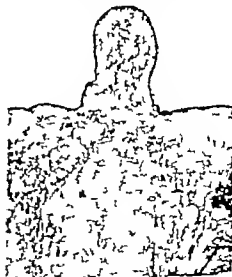


Fig. 6. The similarity of the tissues of the corpus albicans and the papilla constituting the base of an adhesion is apparent. Section of ovary of Monkey No. 34. $\times 70$.



Fig 7



Fig 9

Fig 7 Surface view of ovary of Monkey No 611 to show adhesion Photographed fresh $\times 32$

Fig 8 Section of ovary shown in Figure 7 The adhesion emanates from a corpus albicans $\times 9$

Fig 9 Cut surface of ovary (halved) of Monkey No 660 Current corpus luteum and that of the preceding cycle, with adhesion, are shown

recorded on December 4, 1939, in No 703 was still present February 12, 70 days later

In 3 cases both ovaries were involved

As to the incidence of the ovarian adhesions the writer can give only a rough estimate of perhaps 3 per cent More careful examinations might have resulted in discovery of more cases

PLACE OF INSERTION

In only half of the cases do the records indicate whether the insertion was on the fimbriae or on the omentum and these are

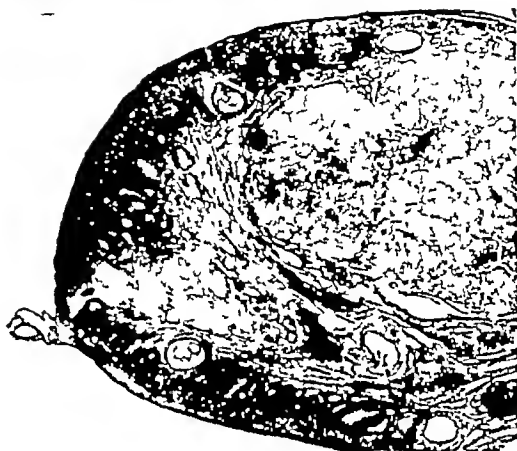


Fig 8



Fig 10



Fig 11



Fig 12

Fig 10 Section of ovary shown in Figure 9, through adhesion and corpus albicans $\times 34$

Figure 11 from the adhesion (upper ring in Fig 10), Figure 12 from the corpus albicans (lower ring of Fig 10) $\times 340$

Figs 11 and 12 Sections of portions of Figure 10,



Figs. 3 and 4. Ovaries of Monkey Nos. 30 and 6391 show papillae that mark the remnants (basal portions) of adhesions that all but disappeared spontaneously.

evenly divided namely 6 on each. As the fimbriae closely envelop the ovary at ovulation time and relax and withdraw from the ovary later it follows that the attachments to the fimbriae probably occurred early in the life of the corpus luteum as compared with the attachments to the omentum.

RELATION OF ADHESIONS TO PRIOR OPERATIONS

The question has already been raised (in connection with No. 324) as to whether the adhesions described are the result of trauma at prior abdominal operations or after hysterotomies, adhesions are of course common. A survey of the series however shows that in nearly half of the animals the adhesions were discovered at the first laparotomy. Generalized spontaneous adhesions of abdominal organs are rare in the rhesus monkey. 2 records only are available in our protocols so far as these have been searched.

SUMMARY AND CONCLUSIONS

It is concluded that in the rhesus monkey certain strands of tissue here described as running from the ovary to the tubal fimbria or to the omentum arise by ingrowth of connective tissue and blood vessels into a scaffolding of viscous and tenacious liquor folliculi having as a thread from a fresh corpus luteum. Such strands have been seen in the making and their persistence has been followed by subsequent laparotomies. Older adhesions are often traceable to corpora albicantia and

luteal tissue may be found in the proximal ends of the strands. Even delicate thread have been shown to persist as long as 70 days; more robust ones probably last very much longer. In a cases the adhesions proved to be evanescent structures disappearing spontaneously. Certain papillae on the surface of the ovary may be remnants of such adhesions, as was proved in 1 case.

Whether such adhesions occur in women also the writer does not know. Perhaps such are brushed off by the surgeon as insignificant. It is conceivable that if they do occur in women as in the monkey female they at times cause a slight discomfort. Dr. G. W. Corner (personal communication) saw in a monkey an adhesion strong enough to have held an entangled loop of the intestine and possibly caused strangulation.

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SURGICAL APPROACH FOR TUMORS OF THE THYMUS

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THERE probably is no organ in the human body about which physicians have as little definite knowledge as they have about the thymus. The following quotation is from an editorial (5) which appeared in the *Lancet*: "The thymus gland has remained an enigma. Endocrinologists have wooed it in vain. Physiologists and pathologists have drawn away from it baffled. Not even the anatomists or histologists have spoken of it with their customary precision for we are still uncertain whether it has any real existence in the normal adult and whether the main cells of its medulla are to be regarded as epithelial or endothelial." In recent years, however, there has been a considerable interest in this organ and, although it must be admitted that there is very little definite scientific knowledge about the thymus, there has accumulated a considerable body of evidence suggesting a relationship between abnormalities of this gland and the disease, myasthenia gravis. This association was first noted by Weigert, in 1901. Since that time, Bell, Norris, Blalock (3) and his associates (4), and others have contributed considerable evidence to support the thesis that abnormalities of the thymus manifest by enlargement or tumors of this organ occur in a much higher percentage of cases of myasthenia gravis than can be accounted for by coincidence. Further evidence of the association of myasthenia gravis and the thymus is that in selected cases deep roentgen therapy applied over the thymus has produced a remission of symptoms. In recent literature there have been reports of cases of myasthenia gravis in which this treatment has produced improvement and in some instances complete remission of symptoms has occurred.

The purpose of this paper is to consider the three main surgical approaches to lesions of the thymus gland, all of which have been em-

ployed by one of us (O. T. C.). The clinical results in 10 cases in which thymectomy was performed will not be considered at this time except to say that there has been but 1 death and the results have been satisfactory, in fact, sufficiently so to warrant further employment of thymectomy in cases of myasthenia gravis and, at times, even in cases in which there is no demonstrable thymic enlargement evident on x-ray examination of the thorax.

EMBRYOLOGIC AND ANATOMIC CONSIDERATION

The thymus gland (2) takes its origin from the 3d visceral cleft of each side and consists of two lobes, one of which is formed from each lateral diverticulum. The upper part is at first tubular but gradually becomes a solid structure. The thymus is believed by many investigators to be originally epithelial in structure, reaching its maximum growth and finally becoming mainly lymphoid in type by the end of the second year. The gland remains essentially stationary in growth until puberty, after which it rapidly atrophies.

The two lobes of the thymus lie in the midline in close contact with each other and extend from the lower border of the thyroid gland to the 4th costal cartilage. In the neck, the thymus rests on the trachea and is covered by the sternohyoid and sternothyroid muscles. In the thorax, the gland lies directly beneath the sternum, it rests below upon the pericardium, being separated from the aortic arch and large vessels by a thin layer of fascia.

The blood supply of the thymus is derived from branches of the internal mammary and superior and inferior thyroid arteries. The blood returns by way of the innominate, internal mammary, and the thyroid veins. The nerve supply to the gland substance is derived from sympathetic fibers and branches of the vagus. The thymic capsule is further supplied by branches of the phrenic and descending hypoglossal nerves.

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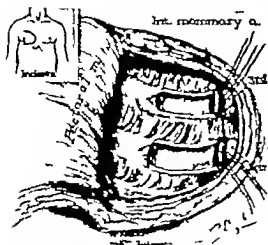


Fig. 1. Transcostal approach. Inset shows line of incision. The pectoralis major muscle is turned back, then exposing the costal cartilages and internal mammary vessels.

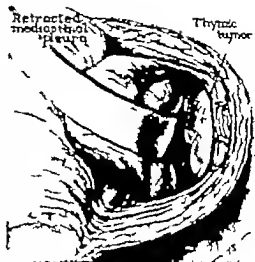


Fig. 2. Transcostal approach. The pleura is retracted laterally and the thymic tumor protrudes from beneath the sternum.

SURGICAL APPROACHES

Three different surgical approaches for tumors of the thymus gland have been used depending on the size and situation of the tumor and also on whether extensive irradiation has been used previously and has resulted

in greater fixation of the lesion. Any one of these approaches will permit adequate exposure of the thymus which we do not believe to be the case in all instances when the tumor is approached through an incision in the neck. The anterior transcostal and the sternum-

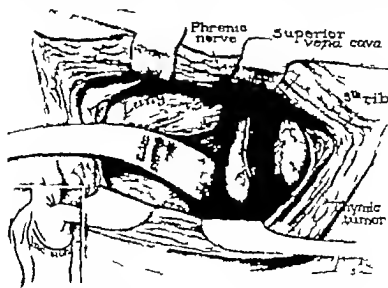


Fig. 3. Posterolateral approach. Inset shows the line of incision. A long segment of the 5th rib has been removed. The lung is packed off to one side, then exposing the thymic tumor in the anterior mediastinum.

splitting approaches are entirely extrapleural, whereas the posterolateral approach involves opening the pleural cavity. The advantages, disadvantages, and technique of each approach will be considered.

Transcostal approach This approach has the advantage of being not only an easy one to make but also one through which the operation may be performed extrapleurally, however, the exposure is not too satisfactory. This approach should be used only when the tumor is known to be a relatively small one and when there has been no extensive use of irradiation therapy.

The patient is placed on his back and a curved incision is made through the skin and subcutaneous tissue on the anterior thoracic wall. The pectoralis major muscle is turned back, which exposes the 3d and 4th costal cartilages (Figs 1 and 2). The internal mammary vessels are isolated just lateral to the sternum and are doubly ligated. Two to 3 inches (5 to 7.6 cm) of the 3d and 4th costal cartilages then are resected. The intercostal vessels are ligated and the posterior perichondrium is incised in a vertical direction just lateral to the course of the internal mammary vessels. By means of blunt dissection with the index finger, the pleural margin is located and retracted laterally. The thymus is then readily freed from the loose surrounding areolar tissue, and the thin extrapleural fascia, and is removed from the thorax. In some instances the thymus is quite firmly fixed to surrounding structures, thus necessitating the use of sharp dissection and accurate control of all bleeding points. Three to 5 grams of some chemotherapeutic agent then may be inserted and the operative site is drained with a Penrose drain. The vertical margins of the incised posterior perichondrium are approximated with interrupted sutures. The pectoralis major muscle is allowed to fall back into its normal position and the subcutaneous tissues are closed with interrupted sutures of plain catgut. The skin is closed with either interrupted sutures or a running locking dermal suture.

Posterolateral approach This approach permits the most adequate exposure for very large thymic tumors or for those which are

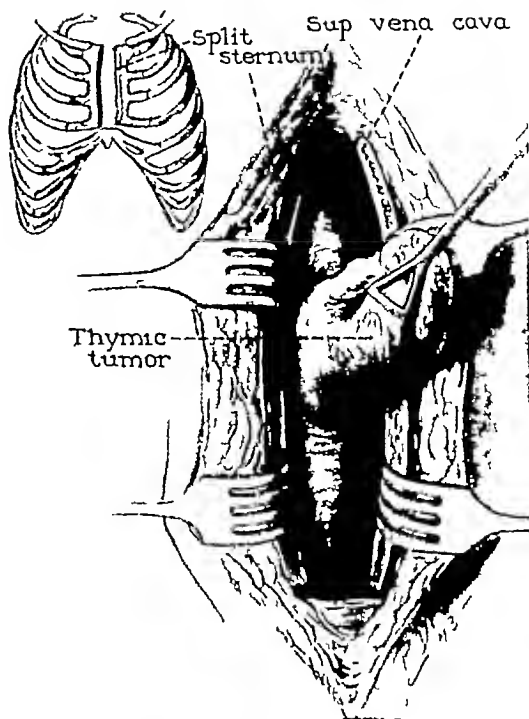


Fig 4. Sternum splitting approach. Inset shows the extent of the opening in the sternum. The sternum has been split and its edges have been retracted. The thymic tumor can be exposed readily directly beneath the sternum.

fixed to the surrounding vessels. With this approach, however, it is necessary to open the pleural cavity and, although the danger is slight, one must accept the complications which do occur occasionally when the pleural cavity is opened, such as atelectasis resulting from unsatisfactory re-expansion of the lung, or empyema resulting from infection. A technical disadvantage to this approach is that the surgeon is working at the end of instruments, which is not the case when the anterior approach is used.

The patient is placed on either side, depending on the situation of the tumor, and is strapped firmly into position. A curved posterolateral incision is made on the right side. The incision is begun midway between the edge of the scapula and the vertebrae and extended laterally beneath the scapula (Fig 3). The trapezius and rhomboid muscles are incised superiorly, while the latissimus dorsi and portions of the anterior serratus muscles



Fig. 5 The Lebsche sternum splitter

are incised inferiorly. The scapula then is elevated and the 5th rib is localized. With the use of the Alexander periosteal elevator the periosteum is carefully freed from the rib and a long segment of the rib is resected. All bleeding usually stops when the rib is removed but on occasions the intercostal vessels and nerves must be ligated. The posterior periosteum of the rib bed and the parietal pleura then are incised which allows one to open the pleural cavity directly. The lung becomes deflated and may be packed aside with a moist gauze pack which permits excellent exposure of the mediastinum and its structures. The mediastinal pleura then is incised over the tumor and the thymus is removed by either blunt or sharp dissection depending on the amount of fixation present. After the tumor has been removed and hemostasis is accomplished, the operative site is washed with physiologic salt solution and 5 grams of sulfanilamide or an equivalent amount of sulfanilamide is sprinkled into the thorax. The opening in the mediastinal pleura then may be closed. Usually a rubber catheter is inserted through a stab wound made one intercostal space below the incision in the posterior axillary line. The anesthetist then employs a positive pressure of 10 to 12 millimeters of mercury which is sufficient to re-expand the lung. While the thorax is being closed constant suction through a rubber catheter is employed. This suction plus the positive pressure anesthesia, aids in maintaining satisfactory re-expansion of the lung during closure. As an assistant approximates the edges of the wound the wound is closed with a continuous running suture of chromic catgut in the parietal pleura and periosteum of the rib bed. The muscles are approximated with

interrupted sutures. A few interrupted sutures are placed in the subcutaneous tissues and the skin is closed with a continuous locking dermal stitch. Water seal suction is applied to the catheter for 24 to 48 hours at the end of which time the catheter is removed if roentgenographic examination of the thorax reveals that the lung is well expanded. Care must be taken at the time of removal of the intercostal tube to avoid having any air enter the thoracic cavity.

Sternal splitting approach. This approach permits the most direct access to the thymus and is the one favored in most instances. Owing to the situation of the thymus immediately beneath the sternum, its separation from the superior vena cava, the arch of the aorta and the pericardium may be carried out most readily by such a direct approach. The operation is carried out entirely extrapleurally—another favorable factor. The only disadvantage is that one still does not have the surgical exposure which can be obtained with the posterolateral approach.

With the patient lying on his back a midline incision is made beginning 1 inch (2.5 cm.) above the manubrium and extending to the 4th costal cartilage anteriorly (Fig. 4). The soft tissues at the base of the neck are freed from the manubrium and the sternum is exposed in the midline throughout the length of the incision. The Lebsche sternum splitter, a fairly heavy instrument with a sharply curved surface at one end (Fig. 5) then is hooked under the manubrium and with the use of an orthopedic mallet the sternum is split to within about 2 inches (5 cm.) of the xiphisternal junction. At this point transverse incisions are made through the sternum to allow wider retraction of the sternum. With sharp retractors, the sternal margins are retracted and exploration of the anterior mediastinum is then possible. The thymus is found lying directly beneath the sternum and is removed as in the previous instance, by blunt dissection when possible or by sharp dissection when necessary. After all bleeding points have been ligated 5 grams of sulfanilamide is placed in the wound and one Penrose drain is inserted. The sternal margins are approximated with steel wire turn-

REVIEW OF CASES

CASE 1 A S M, the patient, a 40 year old white farmer's wife, was first admitted to the hospital on September 2, 1943, with a history of progressive weakness of 12 years' duration. At the onset, she had noted a drooping of the left eyelid, which spread to involve the right eye. She had had mild diplopia on looking downward. Some 9 years prior to admission, weakness of the shoulders had become so severe that she was unable to hold the arms above the head. The condition had progressed until 4 years prior to admission she was having extreme difficulty in swallowing and talking, there was a constant drooling of saliva, due to inability to close the mouth. Two years prior to admission, the weakness had involved the hands, the first motion was performed rather easily, but repeated or sustained motion resulted in marked weakness and incoordination of motion. Fifteen months prior to admission the weakness extended to the lower extremities, associated with shortness of breath, and progressed to such an extent that the patient had to remain in bed. The diagnosis of myasthenia gravis was first made at the North Carolina Sanatorium for the Treatment of Tuberculosis, in August, 1940. She was a patient in that institution for 4½ months, where a diagnosis of moderately advanced apical tuberculosis was made, but the tubercle bacillus was never demonstrated in the sputum. She had no clinical evidence of active tuberculosis at that time, the diagnosis was based on x-ray findings.

She had been given prostigmin methylsulfate, 3 15-milligram tablets had been given daily, some improvement was noted over a period of 4 or 5 months. The dose was gradually increased to as high as 12 15-milligram tablets in a 24 hour period. The patient had often had to take the medication throughout the night because of respiratory difficulty. One year prior to admission, she was studied at another hospital, and the dosage of prostigmin temporarily decreased, with the addition of guanidine hydrochloride.

A review of the past history revealed pneumonia at the age of 15 years and repeated bouts of malaria at the age of 30, after the onset of the symptoms of myasthenia gravis. During the 3 years prior to admission, she had noted an irregularity of the menses, with intervals as long as 2 months, the periods lasting 4 to 7 days. Marked vasomotor instability had also been noted. There was no relief of myasthenic symptoms during pregnancies. She had lost approximately 25 pounds in weight during this period. There was no familial history of a similar muscular weakness, tuberculosis, or malignancy.

On physical examination the patient was found to be extremely weak, the weakness was much more pronounced on sustained or repeated muscular effort. She was unable to talk distinctly for any length of time, and in order to speak she had to manipulate the jaw with a supporting hand. She was unable to raise the unaided hand to the forehead because of

weakness of the shoulders. Swallowing was accomplished with much difficulty. Respiration was shallow and rapid, and there was very little movement of the costal margin or anterior abdominal wall. The eyes were in fixed position, the lids half closed, and she was unable to open or close them. The head was carried in a semiflexed position, the neck being flaccid. There was some diminution in the weakness over the lower trunk and extremities. The head was symmetrical, without scarring or tenderness. Examination of the eyes revealed that the pupils were small, but reacted poorly to light, there was a failure of convergence. Examination of the ears revealed the canals and drums to be clear. The fundi had normal cupping of the discs and normal vascular pattern. The tongue protruded slightly to the right, there was a complete edentia. The deep tendon reflexes were intact and equal throughout. The plantar response was flexor. There was no myoclonia, and no fibrillary muscular twitchings were observed.

The accessory clinical findings were as follows. The urine was entirely normal. The hemoglobin was 12 grams. She had a red blood count of 4,500,000, and a white blood count of 5,200, with an entirely normal differential count. The nonprotein nitrogen was 32 milligrams per cent. The blood calcium was 10.8 milligrams per cent, the phosphorus 4.4 milligrams per cent. The corrected sedimentation rate was 10 millimeters. The blood Kahn was negative. The glucose tolerance test revealed a fasting blood sugar of 89 milligrams per cent, with a level of 125 milligrams per cent after 30 minutes, 147 milligrams per cent at 1 hour, 156 milligrams per cent at 1½ hours, and 105 milligrams per cent at 2 hours. The tuberculin test, using a dilution of 1:10,000, was negative at 24 and 48 hour intervals. Repeated sputum examinations, as well as examination of stomach washings, revealed no acid fast organisms. The skull films were negative, and a chest film revealed a clouding at the right apex, with small, discrete infiltrations radiating from the left hilum into the infraclavicular region of the left upper lobe, with stringy, fibrous strands in this region. No mediastinal tumor could be seen. The plate was interpreted as showing a left upper lobe tuberculosis, with questionable activity. Repeated chest films on this admission revealed no change in these findings. The chest films were repeated after the injection of 250 cubic centimeters of air into the anterior mediastinum, but no tumor or abnormality could be demonstrated.

Intra-arterial injection of 0.2 milligram of prostigmin, with a blood pressure cuff in place, gave marked local improvement in muscular strength, the remaining parts of the body remained weak. There was no fasciculation noted in the injected arm. No abdominal cramps were noted upon release of the pressure in the sphygmomanometer cuff.

During her 22 day stay in the hospital, she was given combinations of glycine, ephedrine, and oral prostigmin without benefit. She was finally stabil-

EXPLORATORY ANTERIOR MEDIASTINOTOMY IN THREE CASES OF MYASTHENIA GRAVIS

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THE purpose of this paper is to summarize and add 3 additional cases to the growing literature on the value of surgical intervention in myasthenia gravis.

The relationship between myasthenia gravis and the thymus gland was first suggested by Weigert in 1901 who found a tumor of the thymus in a postmortem examination of a patient who had died with myasthenia gravis. Schumacker and Roth first reported the operative removal of a thymic tumor by Sauerbauch in 1912. Haberer reported a partial thymectomy on a patient in 1917. Two additional cases by Sauerbauch were reported by Adler and Obidiasch in 1937. Blalock (4) and the Vanderbilt group reported the first successful removal of a cystic thymic tumor in a case of myasthenia gravis with a 4 year follow-up showing definite improvement. In a survey of the literature Poer, using the figures of Bell, Norris, and Blalock and collected data of personal cases, compiled a total of 139 instances of myasthenia gravis in which the thymus was examined at autopsy or operation. This study revealed thymic abnormalities in the form of persistence, enlargement or tumor of the thymus in 71 instances, or 55 per cent of the total cases. Poer (Table 1) also reported 1 case of the successful removal of a malignant tumor of the thymus in a patient with myasthenia gravis with marked improvement in the patient's symptoms at the end of 3 months.

The first concerted effort to influence the course of myasthenia gravis by surgical intervention was carried out by Blalock, Harvey Ford, and Lilienthal (5) at Johns Hopkins Hospital in 1941. Their report is based on 6 cases of myasthenia gravis in which an ante-

rior exploratory mediastinotomy was done. In none of these cases was there roentgenographic evidence of a mediastinal tumor. There was a definite persistence of thymic tissue in all of the patients, but no tumors were found. Definite hyperplasia was demonstrated in all but 1 case. There was 1 death, marked improvement in 3 patients and very little improvement in 2 patients at the time of publication of the study of these cases. In a subsequent communication from Dr. Blalock (3) he states: "During the past eighteen months we have removed the thymus from fifteen patients. None of these showed a tumor. Approximately half of the patients are markedly improved, some of the others have shown no improvement. Campbell *et al.* reported the removal of a thymic tumor in each of 2 cases of myasthenia gravis at a meeting of the New York State Medical Society in 1941. The first patient died suddenly on the 2d postoperative day, while the procedure on the second patient was moderately successful.

The Mayo Clinic reports (7) that in 9 of the last 55 cases of myasthenia gravis studied there was roentgenographic evidence of mediastinal tumors. In 5 of these cases surgical intervention confirmed the presence of tumor. A 6th patient was found to have a persistent thymus gland with tumor formation. Two of the patients who had thymic tumors were operated on during remissions, apparently induced by roentgen irradiation, and they have remained well. In 2 other cases the course of the disease was not influenced by removal of the tumor. One patient with tumor and 1 with a persistent thymus have been operated upon too recently to evaluate.

In the case reported by Turnbull in which a 7.5 by 4 by 2.5 centimeter tumor weighing 10 grams was removed, no improvement was noted at the end of 4 months. The tumor was described as a malignant thymoma of the lymphosarcoma type.

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All patients were studied on the medical service prior to operation on the surgical service at the North Carolina Baptist Hospital.

weakness in the neck muscles, and there was marked tiring on the performance of any continuous muscular effort. The deep reflexes were moderately hypoaactive throughout, but the abdominal reflexes were normal. Examination of the eye grounds revealed nothing remarkable and the gait and station were not disturbed in any specific way. However, there was motor weakness affecting all parts of the body. The sensory function was normal throughout.

Accessory clinical findings revealed the urine to be entirely normal. Blood hemoglobin was 105 per cent, red blood count 5,300,000, white blood count 9,500 with a normal differential. Lumbar puncture revealed the spinal fluid to be normal throughout. The spinal fluid and blood Kahn were negative. Visual fields were full throughout. Skull plates were negative. The initial examination of the chest films were interpreted as showing an enlarged lymph node in the right hilar region.

During his 12 day stay in the hospital it was found that the right lateral rectus paralysis was much improved in the early morning. A diagnostic dose of prostigmin methylsulfate, 2.5 milligrams subcutaneously resulted in definite improvement in the voice, swallowing, disappearance of the ptosis and diplopia, the beneficial effects lasting from 2½ to 3 hours. Ergographic tracings made prior to and following the injection of prostigmin also showed a marked increase in strength. Also intra arterial prostigmin methylsulfate with a manometer cuff in place resulted in the typical myasthenic response. The use of guanidine hydrochloride in the relief of symptoms was unsuccessful. He was stabilized with 15 milligrams of prostigmin bromide 3 times daily, and with oral tincture of belladonna. He was also given 1,350 roentgen units of x ray therapy in fractional doses over anterior neck and upper mediastinum.

He was admitted to the hospital for the second time on October 3, 1942, his prostigmin bromide having been gradually increased to 15 milligrams every 2 hours, in an effort to control his symptoms. He had also been given ephedrine apparently without effect. He had gained 10 pounds in weight and his general health had been unchanged. It was interesting to note that at times the prostigmin had been ineffective when taken shortly after meals.

His physical examination was essentially unchanged, and in spite of the fact that the patient had been under the influence of prostigmin when seen there was a slight right abducens palsy and moderate tiring on the performance of any motor function. Neurological examination was otherwise normal.

Ergographic studies were carried out which showed the decreased efficiency of prostigmin taken after meals was due to decreased absorption of the drug.

During his 25 day stay in the hospital he was given a 3 hour ether anesthesia without any apparent effect on the severity of his myasthenic symptoms. This was done because of the possibility that the beneficial effect reported from thymectomy might be due to the anesthetic agent's effect on the acetylcholine and cholinesterase imbalance.



Fig 1 Case 2 Tumor present in lower third of mediastinum

He was readmitted to the surgical service on November 24, 1942, for surgical intervention. At this time he was taking 100 milligrams of prostigmin bromide daily and was still unable to do any work. Repeated chest films at this time with 200 cubic centimeters of air injected into the anterior mediastinum revealed the previously described lymph node to be a discrete tumor approximately 5 centimeters in diameter at about the level of the fifth costochondral cartilage (Fig 1). Obviously, the previous x ray therapy was not directed at this area.

On December 1, 1942, under intratracheal cyclopropane, oxygen, and ether anesthesia an exploratory mediastinotomy was done. Essentially the same approach was used as in Case 1. A well developed thymus gland occupying its normal position in the upper strait of the anterior mediastinum was first removed. It measured 8 by 2½ by 1½ centimeters. Identification of the tissue was made by frozen section at the operating table. Exploration at the level of the sixth costochondral junction on the right revealed a well circumscribed encapsulated tumor lying against the base of the aorta, and incorporating part of the right anteromedial mediastinal pleura. It was removed *in toto*.

The postoperative course was rather stormy, marked by two "sinking spells" on the 2nd postoperative day due to an inadequate dosage of prostigmin. His temperature reached 38.8 degrees C, and the chest film confirmed the clinical impression of a right lower lobe pneumonitis, with some widen-

TABLE 1.—RESULTS OF SURGICAL INTERVENTION IN MYASTHENIA GRAVIS

Author	No. cases	Gross pathology	Results		
			Improved	Unimproved	Died
Marshall and Roth 14		Thyroid large 40 grams			
Habener 144		Thyroid invaginated			
Adler 1927		Bovine tumor 4 cm			2 days malnutrition
Olschick 1937		Bovine tumor 4 cm			3 days atrophy of masticator
Khalck et al 1939		Bovine tumor 6 cm	Well after 7 years		
Campbell et al 41		Bovine tumors in both			not day
Khalck et al 1941		Thyroid large as old No tumors			
Peck 34		Malignant tumor			
Turnbull 1941		Malignant tumor 175 cm			
Chaput 443	6	3 tumors in 3 Fibrous thyroid			operable
Brachman 64		Tumor in Thyroid large as bovine tumor 100			
Total	47	No tumors			

used on 5 milligram of oral prostigmin 6 times daily and 1/4 milligram hypodermically before each meal. She was also given 4 milligrams of glycyne 4 times daily and 15 milligrams of ephedrine every 3 hours. On this regimen she remained very calm, but was able to sit up some in the mornings and felt much stronger than previously. Because the patient is unable to remain ambulatory in her present situation exploration of the anterior mediastinum was decided upon in the hope that some thymic abnormality could be found.

On September 5, 1941 under intratracheal cyclopropane ether and oxygen anesthesia, exploratory anterior mediastinotomy was carried out. The mediastinum was entered through an angular incision extending from the hyoid region down the midline of the sternum to the third sternocostal and then through the right sternal margin. The sternum was split in the midline with Gigli saw and the anterior thirds of the right first, second and third ribs, and portion of the sternum were retracted laterally thus exposing the upper third of the mediastinum. A careful exploration as carried out from the level of the hyoid bone as far down as the cardiac notch. The large vessels were exposed, and a careful search was made for the thymic gland. At several suggestive points extensive dissection was carried out, but frozen sections revealed only fatty tissues. The patient postoperative course was not remarkable and he was discharged on the eighth postoperative day. She was kept in oxygen tent for period of 4 hours immediately after operation and given several blood transfusions. She was given milligram of prostigmin hypodermically every 3 hours until she had fully reacted from anesthesia and this period of 24 hours resumed the 1/4 milligram of prostigmin, glycyne, and ephedrine

The condition of the patient as last evaluated on March 6, 1942, at which time she stated that she was much improved and could stay up from 9:00 a.m. until 9:00 p.m. without requiring rest periods. She had continued to take between 3 and 7 3-milligram tablets of prostigmin daily during her waking hours. Her eating was more pronounced in the mornings and required prostigmin before getting out of bed. The prostigmin had been taken only as needed by the patient, and she stated that she could often go 3 hours without any medication. On this dosage there was no further diplopia, dysphagia, dysphagia. Ergographic tracings, compared with those taken prior to operation, revealed no improvement.

CASE S.P. aged 4 years, bit male mill-worker was first admitted to the medical service on June 1941 with symptoms of 3 months duration. The symptoms of blurring of vision in the left eye upon sustained use was usually relieved by resting. He also noticed some dysphagia and dysphagia, the dysphagia progressing to the point of being unable to ingest of liquid material. The weakness progressed and involved the extremities to the extent that by mid-morning the strength of his legs gave way, resulting in his collapse to the floor.

At the time of admission the patient was able to chew only few mouthful of food, had periods of complete loss of voice and was unable to hold his head erect.

Physical examination revealed temperature of 37 degrees C, pulse 80, respiration 18, and blood pressure 106. The general physical examination was essentially normal throughout. The post-neurological findings were as follows: There was ptosis of the left upper lid. There was paralysis of the right lateral rectus muscle. There was

some definite impairment of convergence. There was no noticeable ptosis of the lid. The patient tired easily on counting or on other repeated activity requiring muscular coordination. The heart and lungs were clear. There was a marked increase in reaction to dulcinea. The reflexes were active and equal throughout. There were no pathological signs. The patient was unable to raise her head and sit up in bed without help.

Necessary clinical laboratory examinations: Red blood count, 4,500,000. Hemoglobin, 12 per cent. White blood count, 11,000. Differential, 60% polymorphonuclear, 35% mononuclear, 5% lymphocytes. Erythrocyte sedimentation rate, 15 mm. per hour. Urinary sediment negative. Her basal metabolic rate was plus 10 per cent. The x-ray film of the chest after the injection of contrast medium of air into the anterior mediastinum revealed a small rounded lobulated shadow in the roof of the right lung anterior to the root of the vertebral column. There was no question as to whether the shadow was due to a mediastinal tumor or a dilated aorta. Test doses of protigmin, 0.5 cc., had marked relief of symptoms as attested by ergograph tracings made before and after the use of the drug. The intraarterial protigmin test gave significant results. Protigmin in that dose was given daily. There was initial pain with vasodilatation but in a period of 3 or 4 minutes there was marked decrease in strength in the tested arm. The preoperative drug requirement was easily established at 60 milligram of protigmin bromide daily supplemented with 3 milligram of ephedrine.

On May 1, 1913, an exploratory mediastinotomy was carried out. The incision was 3 cm. long as in the previous case. However, the surgical approach was altered somewhat in that the right third rib was removed by a partial resection. The anterior mediastinum was then opened along the right anterolateral margin. The mass of tissue measuring 6" by 3 centimeter, which appeared all encapsulated and of thymic origin was removed from the anterior surface of the descending aorta. An excellent exposure of the anterior mediastinum was obtained and a careful search was made for further thymic tissue.

The patient's postoperative course was entirely uneventful. She was discharged on her fifth postoperative day. At the time of discharge she was receiving approximately 5 milligrams of protigmin bromide 3 times daily before meals.

The patient was seen in the outpatient department on June 29, 1913, complaining of weakness and anorexia. She had been unable to stay out of bed over 3 hours at a time. However, her dysphagia and dysphoria had disappeared. She was taking 7½ milligrams of protigmin bromide 3 times daily. The dosage was increased to 3 1/2 milligram tablets daily.

She was last seen in the outpatient department on September 8, 1913, some 14 weeks after operation. She continued to have extreme generalized weakness, having to spend the afternoons in bed. Appetite had improved but diet was confined to soft foods.

There was no improvement in spite of protigmin 30 minutes before meals. She still exhibited the tendency to climb on her bed upon getting up from the examining table. There was a mild ptosis of the left lid and loss of convergence. Her protigmin was again increased and potassium salts added to her diet.

In Case 1 there was no definite thymic tissue removed and certainly no objective improvement in the status of the patient's myasthenia gravis. In the light of our experience in the location of the tumor in Case 2 a more thorough search of the lower third of the anterior mediastinum would seem to be indicated. This is particularly true when one considers the wide variation in location of aberrant thyroid tissue. Remnants of thymic tissue have been removed from all levels of the anterior mediastinum as well as the neck region. Foster Kennedy studied 8 consecutive cases of myasthenia gravis at postmortem examination and found no frank tumors but in 5 cases there was a paper thin sheet of thymic tissue covering the pericardium.

In Case 3 prior to operation the roentgen therapy was confined entirely to the anterior neck region and therefore certainly could not have covered the area of the tumor lying under the fifth and sixth costochondral cartilages. This therapy was given before demonstration of the tumor by the air injection. It is interesting to note that the focus of attention was directed toward the superior rather than the anterior mediastinum where the thymus is thought to be more commonly located. However, it has been previously pointed out by Blalock *et al.* that the thymus is situated almost exclusively in the thorax rather than the neck.

The result in this patient is extremely difficult to evaluate because of the development of an acute duodenal ulcer complicated by severe repeated hemorrhages. The patient was very uncooperative, refusing to follow his diet or to consider any operative procedure. In spite of his severe secondary anemia he continues to have a good range of activity unless than half of his preoperative requirement of protigmin.

The tissue removed from this case consisted of an essentially normal thymus measuring 8 by 2.5 by 1.5 centimeters. The flattened,



Fig. 2. Case 5. Pulmonary tumor.

ing of the mediastinum. However he responded readily to increased dosage of prostigmin and sulfadiazine. He was discharged on the 5th postoperative day on 1/4 of 5 milligram tablet of prostigmin or 3 times daily.

On his fourth admission to the hospital on February 3, 1935, his symptoms of myasthenia gravis were much improved. He was able to resume his former occupation, but taking approximately 5 milligrams of prostigmin bromide daily. However he had developed classical signs and symptoms of peptic ulcer: those of hunger, epigastric pain, food and relief. He found it had slight pain of the right epigastrium, the distant lateral rectus palsy on the right. The median trachea was still healed. There was point tenderness to pressure in the deep epigastrium. His blood calcium level was 9.4 milligrams per cent. His blood phosphorus was 4.4 milligrams per cent. His stool examination was negative for occult blood. His total caput was 5400 cubic centimeters. Gastric analysis revealed 0 degree of free acid before histamine stimulation and 0 degree after histamine stimulation. The chest film was not remarkable; the anterior mediastinal mass seen before operation had been totally removed. A gas roentgenogram had revealed marked pylorospasm, the persistent deformity of the duodenal cap. The roentgen impression that of nonobstructing duodenal ulcer. The roentgen tracings compared with those preceding operation showed a definite improvement on less

prostigmin. The response to intra-arterial prostigmin was still definitely myasthenic in character. He was given bland diet, frequent feedings, typhoid mix, and ampicin.

He was again seen in the outpatient department on July 1, 1935, with a history of massive hematemesis, with associated tarry stools. He admitted that he had not followed his ulcer regimen. He had been working full time as a truck driver. He continued to have bouts of calicose approximately 10 hours after his noon meal, which were not effected by oral prostigmin. He refused admission to the hospital.

He was seen again on July 30, 1935, and his condition remained stable. He continued to have tarry stools and occasional bout of diarrhea. His prostigmin requirement was 4 to 5 5-milligram tablet daily.

He was readmitted on July 30, 1935, for further study. Esophageal tracings revealed the inefficiency of his oral prostigmin following his noon meal. This was overcome by the use of the soluble form given subcutaneously.

Re-examination of the chest by fluoroscope showed the lung fields to be clear. No mediastinal masses were seen. There was slight narrowing of the intercostal spaces on the left, the evidence of an old pleurisy in the costophrenic angle. The heart of normal size appeared normal. No evidence as seen of recurrence of the mediastinal mass. His basal metabolic rate was minus 4 per cent. His glucose tolerance curve (5 hour test) was entirely normal. On this admission to the hospital, the patient extremely unco-operative and he admitted that he probably could not stay on his ulcer regimen. He was last seen in the outpatient department on August 5, 1935, when he was taking approximately 45 milligrams of prostigmin bromide daily (less than half peroperative requirement). There were clinical signs of severe secondary anemia and he got tired of passing repeatedly large tarry stools. He refused to follow his diet or to be admitted to the hospital for further treatment and therapy.

C. J. M. O. L. white female, age 30, married, admitted on May 3, 1935, with a history of onset of symptoms of calicose of the jaw, dysphagia and phosia in March, 1934. The symptoms were transitory and mild and lasted only months. However these same symptoms returned in March, 1935, with typical loss of good strength in the morning becoming progressive. Earlier in the day of admission, he had noticed drooping of the left eyelid and blurring of vision after use of the eyes. The symptoms progressed until he noticed that he was allowing for time he could regurgitate liquid material through her nose. She was unable to assume the thing position without help.

On physical examination the patient was found to be fairly well nourished and there was definite nasal ectropion of the nose. The tracheal movements were fairly well performed, there was

A SET OF NEEDLES FOR SUTURING THE RENAL PARENCHYMA

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THE purpose of this paper is to describe a set of needles of new design for suturing the renal parenchyma, and also to describe a suturing technique for which they were constructed. No particular claim for originality is made. The needles are of the "open-eye, needle-in-handle" type and employ an old suturing principle. The suturing technique combines certain principles of Deming's suture for closing nephrotomy incisions (1) and Vest's interlocking suture for obliteration of the prostatic fossa after perineal prostatectomy (2). This particular suture is intended primarily for a hemostatic su-

ture in partial nephrectomy, calycectomy, or division of fused kidneys, but is useful in the closure of certain nephrotomy incisions. In this paper I am concerned only with the technical aspects of the procedure and shall present no animal experiments or clinical cases.

The needles (Fig. 1) are constructed of stainless steel and their shafts are made in three shapes, one straight, one a segment of a circle 5.5 inches in

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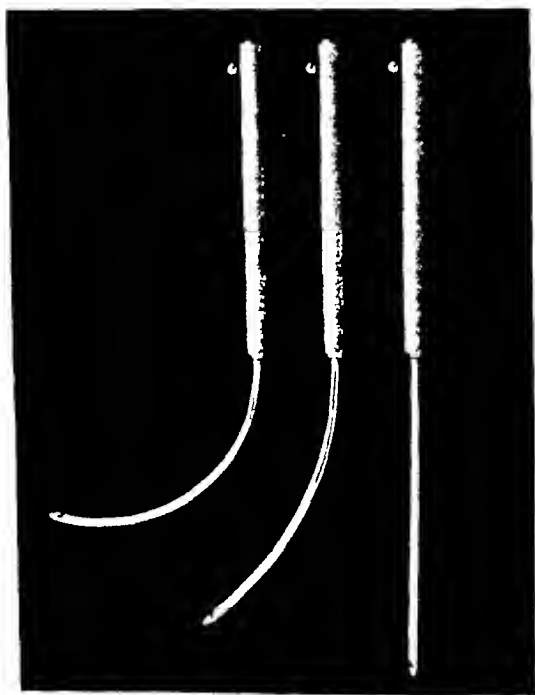


Fig. 1

Fig. 1 Set of open eye needles in handle of different shapes for suturing renal parenchyma.

Fig. 2 Technique of placing hemostatic sutures in partial nephrectomy. Conveniently long segments of a full length suture are introduced with the special needle at appropriate intervals along the incision, as illustrated. Division of the

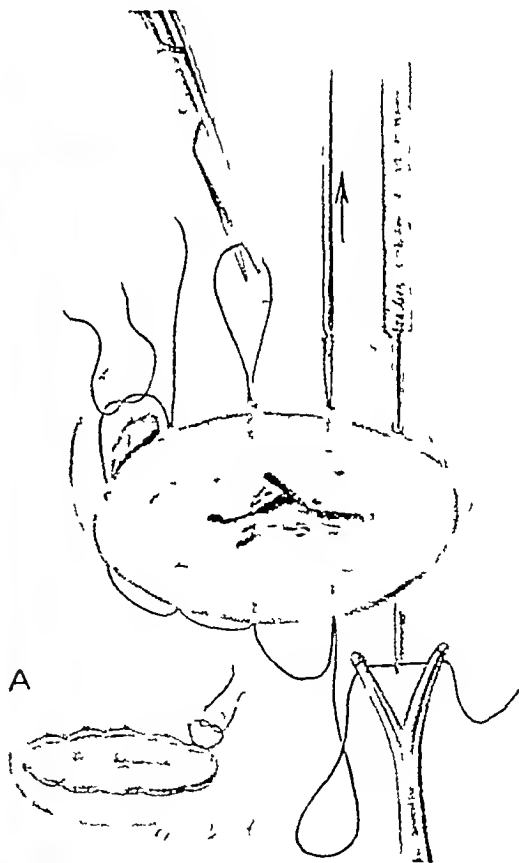


Fig. 2

resulting loops of the suture provides a series of hemostatic mattress sutures which of necessity include the entire cut edge of parenchyma. Inset A shows sutures tied. Pre-ervation of capsule to cover defect, use of muscle in order to prevent cutting, and other steps are omitted for sake of clarity.

TABLE II.—PATHOLOGY IN 132 CASES OF MYASTHENIA GRAVIS

	No.	Percent
Enlargement or persistence	3	3.5
Benign tumors	55	20
Malignant tumors	4	3
Pathological change	73	55.5
\ pathologic change	59	44.5

Figures include samples and operations

Kidney-shaped tumor was entirely separate lying 5 to 6 centimeters below the lowest portion of the thymus as a discrete well encapsulated mass measuring 9½ by 8 by 4 centimeters. On cut section the surface had a soft brownish appearance with considerable fat tissue scattered uniformly throughout the tissue. Numerous large dilated blood vessels could be seen just beneath the capsule. At the lower pole there were 3 small cystic areas from which light yellowish fluid could be expressed. The microscopic structure of the tumor was that of large irregular areas of cell proliferation of the reticulum cell type. The cells varied greatly in size with prominent nucleoli but no mitotic figures. Scattered throughout the tumor were diffuse collections of thymocytes. Dr Robert I. Morehead, pathologist, was of the opinion that the tumor was benign and could be classified only as a thymoma.

In Case 3 the history of a long remission was more suggestive of a hyperplasia of the thymus rather than an actual tumor. The specimen removed consisted of a mass of tissue measuring 6.5 by 3 centimeters weighing 10 grams and was well encapsulated. Upon cut section the central portion of the surface had a sclerotic cystic appearance. Microscopically the tissue studies revealed normal thymic tissue composed of thymocytes and reticular

cells. Hassall's corpuscles were numerous. The striking feature was a large fibrotic area which presented some areas of necrosis. The pathological diagnosis was incomplete involution of the thymus.

SUMMARY

A summary of the literature on the value of surgery in proved cases of myasthenia gravis has been given approximately 50 per cent of these patients have shown improvement. The literature have been added 3 cases in which improvement was noted in 1 and no improvement in the 2 others. We agree with previous authors on the subject that the relationship of the thymus to myasthenia gravis will be more clearly determined after careful correlation of the clinical findings, pathological changes in the gland and the postoperative results in a larger group of patients over a period of several years.

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THE RAPID IDENTIFICATION OF THE CLOSTRIDIUM WELCHII IN ACCIDENTAL WOUNDS

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GAS gangrene and tetanus are the most dreaded infections complicating fresh accidental wounds. The latter has been successfully controlled by the prophylactic use of tetanus antitoxin, and the use of toxoid gives additional promise. For several reasons the use of gas gangrene antitoxin has not been as effective, and merely its use will not prevent gas gangrene.

Gas gangrene is feared so much as a wound complication principally because it is not recognized until the lesion is far advanced. The wounds in which gas gangrene is prone to develop are extensive ones, and their treatment requires the use of large dressings, casts, or splints. These coverings make observations indirect and deductions difficult and uncertain as to the progress of events within the wound. Gas gangrene may develop insidiously beneath the cast and may not be recognized until 48 to 72 hours have elapsed. Once the lesion is sufficiently established to permit a diagnosis from the clinical appearance of the wound, a far advanced and often irreversible process is present. Such delay is costly and results in extensive incisions, unnecessary amputations, and even death. For these reasons, we have attempted to formulate some plan of management of wounds contaminated with gas bacilli which will prevent delayed diagnosis and its tragic consequences.

Gas gangrene is a clinical entity of multiple bacterial etiology. A great variety of gas-producing anaerobic bacteria, chiefly the *Clostridium welchii*, *Clostridium sporogenes*, *Vibrio septique*, *Clostridium oedematiens* and *Clostridium histolyticus*, have been repeatedly found in association with this condition. The individual case usually presents a mixed bacterial flora of aerobes as well as anaerobes. The fact remains, however, that the *Clostridium welchii* is the principal cause of gas gangrene and is present either alone or in association with other gas producing anaerobes. It was found in 72 to 80 per cent of the cases of gas gangrene studied (3) in the World War and has since been consistently found in civilian cases in this country. In the present war, the *Clostridium oedematiens* has been found in association

with gas gangrene on some battlefields, but the *Clostridium welchii* continues to play an important etiological rôle.

The number of gas bacilli contaminating a wound conceivably may be small. Diagnostic smears usually are of little value, particularly if they are taken in less than 12 hours after receipt of the injury or if bleeding is present. The results of anaerobic culture of material swabbed from fresh contaminated wounds are not as accurate as those of tissue débrided from the wound. Careful anaerobic cultures will demonstrate the presence of the *Clostridium welchii* or other gas gangrene producing bacteria, but such anaerobic analysis is of no immediate value to the surgeon because of the specialized technique required and the long time consumed by such examinations. A means of rapid cultivation and simple identification of the *Clostridium welchii* in tissue débrided from wounds should be of considerable value to the surgeon.

The most characteristic known cultural peculiarity of the gas bacillus is its stormy fermentation of milk in 18 to 48 hours under anaerobic conditions (2). Using representative strains of *Clostridium welchii* which we isolated from accidental wounds, we have studied this reaction as

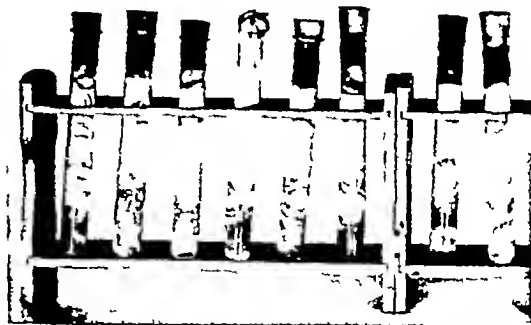


Fig 1 Showing typical stormy fermentation reaction developing within 7 to 7½ hours from culture of contaminated muscle, débrided from experimental wounds Series XIII, March 6, 1941. *Bacillus welchii* Dilutions 107, dose, 0.5 cubic centimeter. Wounds excised in 2 hours.

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diameter and one a segment of a circle 5 inches in diameter. A small projection near the base of the knurled handle marks the position of the needle's eye. The shaft of the needle is rigid, measuring 2 inches in length and $1/16$ in by $1/32$ of an inch in diameter and is abruptly pointed to minimize injury to parenchymal blood vessels. A slot on the concave margin of the needle $1/16$ th of an inch from the tip is of such caliber as to secure and withdraw a strand of No. 2 chromic catgut.

The suturing technique is well illustrated in the drawing (Fig. 1). An appropriately shaped needle is inserted at one end of and close to, the parenchymal incision. The needle is thrust from capsule into pelvis, a closing nephrotomy incision (or through capsule of the opposite side of the kidney in partial nephrectomy, as in the illustration). One end of a full length of No. 2 chromic catgut is placed in the needle's slot by means of a ligature carrier and withdrawn. The needle is then similarly reintroduced to 1.5 centimeters farther along the edge of the incision. The approximate junction of the first and second quarter-lengths of the suture is secured in the needle's slot and withdrawn. The resulting loop is subsequently divided, providing the first quarter length of the suture as a ligature for the first centimeter of the parenchymal incision. Additional convenient lengths of the suture are similarly placed every 1 to 5 centimeters so as to include the entire cut edge of kidney in successive ligatures. Additional lengths of catgut are used, if necessary.

This technique of suturing presents several advantages. It is possible to place the ligating so-

tures very accurately and closer to the cut edge of the kidney than is possible with the usual curved needle. This reduces the amount of renal tissue destroyed by ischemia. Technically, the suturing can be accomplished more rapidly and easily than is possible when either straight or curved needles with sutures attached are employed, as no sutures have to be introduced from the deep, less accessible surface of the kidney. Furthermore, hemostasis should be absolute as the adjacent limbs of the successive ligatures are in apposition and the entirety of the parenchymal incision is of necessity included in the row of sutures.

The straight needle is usually employed for suturing as it permits the most rapid and accurate placement of sutures. The curved needles are used when, because of limitation of exposure, one end of the parenchymal incision is not easily accessible to the straight needle. If a wedge-shaped or curved resection of one pole of the kidney is performed, one of the curved needles may allow placement of the sutures closer to the cut edge of the kidney and thus be preferable to the straight one.

Although originally designed for use in the suturing technique here described, the needles may be used for placing almost any interrupted or continuous suture in the renal parenchyma when the usual method of suturing is difficult because of lack of exposure.

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method simple, convenient, efficient, and practical for this purpose. With our present technique of media preparation and anaerobic cultivation, a typical stormy fermentation is produced in 4 to 10 hours, depending upon the inoculated dose of *Clostridium welchii*, as compared to 18 to 48 hours when autoclaved or desiccated litmus milk was used.

A series of controlled experiments were then conducted in guinea pigs. Under the strictest aseptic conditions, 58 wounds 1 centimeter in length were made through the skin and muscle of the medial thigh or paraspinal region of guinea pigs. The exposed muscle in each wound was then crushed exactly 10 times with a hemostat to devitalize that tissue. Into each wound was placed 0.5 cubic centimeter of a saline dilution up to 10^7 of an 18 to 24 hour brain broth culture containing a known number of living *Clostridia welchii*. This number was determined by plating and incubating for 72 hours 0.5 cubic centimeter of the same diluted suspension at the time of the inoculation of the wound. The number of viable gas bacilli introduced into these wounds varied between 3 to 120. The wounds were then closed by approximation of the skin edges with fine black silk sutures. After intervals of 1 to 5 hours the wounds were excised and all débrided tissue was placed into the preheated and cooled milk medium and incubated anaerobically. Typical stormy fermentation occurred promptly in 4 to 10 hours even when as few as 3 living gas bacilli were originally inoculated into the wound (Fig. 1).

Twenty-eight controls made under identical conditions excepting the inoculation with *Clostridium welchii*, all gave negative reactions except 1 when the excised tissue was introduced into the milk. In spite of our precautions, the 1 control wound became cross-contaminated by *Clostridium welchii* from the guinea pig's hair and skin.

Unless each wound was made with the strictest aseptic technique and carefully controlled, false results were obtained. The hair, skin, and feces of the guinea pig normally contain *Clostridium welchii*, and wounds made without aseptic precautions invariably become cross-contaminated. In our preliminary experiments consisting of 62 wounds not made under aseptic conditions, we had learned that a positive stormy fermentation reaction was given both by the wounds we inoculated and by the controls.

When débrided muscle contaminated with *Clostridium welchii* is incubated anaerobically in this medium the reaction is very typical (Fig. 1). Active gas formation may be observed early, sometimes within 2 or 3 hours due to the rapid

fermentation of the lactose. As the gas formation becomes more intense, coagulation of the milk occurs. The coagulum rapidly becomes contracted and riddled with holes by the gas, and within 5 to 10 hours there is complete separation of clot from whey. The differential characteristic of the reaction is the irregular shrunken coagulum which is floating on top of, or adherent to, the side of the culture tube above the level of the clear whey. The whey has the offensive odor of butyric acid and shows marked hemolysis of the blood introduced along with the débrided muscle. Such a reaction controlled by the examination of hanging drop and stained smear preparations, we believe to be indicative of the presence of *Clostridium welchii*.

A study of other bacteria isolated by us during the past 1½ years from contaminated wounds has failed to show any bacterium, either aerobic or anaerobic, which gives an identical reaction (Figs. 2, 3, 4).

While this reaction is typical of *Clostridium welchii*, some strains of *Clostridium butyricum* or *Clostridium multifementans* may approach or almost equal it in intensity. To find either of these bacteria in a wound would be unlikely, and we have found no report of their presence in wounds. However, if an examination of a stained smear and hanging drop of the whey at the height of the reaction shows the predominant micro-organism to be a gram positive nonmotile bacillus, the presence of *Clostridium welchii* is established since the *Clostridium butyricum* and *Clostridium multifementans* are both motile.

It is true that the active gas-producing aerobes, *Bacillus coli*, and *Aerobacter aerogenes*, may produce active fermentation and coagulation of milk, but the reaction is easily distinguished from that of *Clostridium welchii*. It is much slower, and if it does become sufficiently strong to cause separation of the coagulum and whey, the loose coagulum settles to the bottom of the culture tube and is covered with whey not having the offensive odor of butyric acid. All of the strains of *Clostridium welchii* isolated from human wounds give typical and rapid stormy fermentation reactions in the milk medium.

During the past 2½ years we have used this method successfully at the Cincinnati General Hospital for the rapid detection of the presence or absence of *Clostridium welchii* in over 600 contaminated and infected accidental wounds and it has been of value in the early diagnosis of gas gangrene while the infection is still in the incipient or localized stage (Fig. 5). Whenever the gas bacillus is detected in tissue débrided from a



Fig. 2. Shows types of reaction in milk media produced by the culture of *Bacillus elchii* and other clostridia commonly found in wounds. The *Bacillus elchii* culture is 24 hours old, all others are 5 days old. From left to right, tubes contain *B. welchii*, *B. novyi*, *Vibrio septique*, *B. putrefaciens*, *B. histolyticus*, *B. sporogenes*.

its limitations and possibilities for application to the direct culture of debrided contaminated tissue.

The usual time required for the stormy fermentation of autoclaved litmus milk is 18 to 36 hours with these cultures. This is too long to be of much practical importance surgically. After considerable experimentation, it was found that the speed of this reaction could be greatly increased. The fermentation of the milk is dependent upon the amount of lactose available for bacterial action. A good grade of fresh milk was found to be superior to a poorer grade in which part of the lactose had been converted to lactic acid by the action of such bacteria as the *Streptococcus lactis*. Sterilization by autoclaving caramelizes lactose, and this probably explains



Fig. 3. Reactions produced by the aerobic bacilli of clostridium group and the anaerobic bacilli *metanospirillum* and *streptococcus*. Crespare reaction given by *Bacillus coli* and *Aerobacter aerogenes*. (It should be noted that in the tubes from left to right, tubes contain *B. coli*, *B. aerogenes*, *B. proteus*, anaerobic strep., *B. metanospirillum*.

the superiority of milk media sterilized by heating for 1 hour in a dry oven at 120 degrees C. for 5 successive days. Separation of the cream also added the reaction. The use of any indicator such as litmus not only delays the stormy fermentation but is unnecessary in that the differential characteristic is the type of coagulum produced. For this reason we have omitted all indicators. The time required for the reaction is greatly decreased by the addition of fresh and cooked muscle tissue. Finally stormy fermentation will occur under aerobic conditions in preheated and cooled milk which has been inoculated with the *Clostridium welchii*, but not as rapidly nor as typically as under anaerobic conditions. Our method of anaerobiosis is a modification of Wright's method (2) using pyrogallic acid and Rockwell's solution (3). We have found the



Fig. 4. The results of the cultivation in milk of other bacteria commonly found in accidental wounds is shown. From left to right, tubes contain *Staph. aureus*, *Staph. albus*, *Strep. hemolyticus*, *Strep. indians*, *Nonhemolytic Strep.*, *B. subtilis*.



Fig. 5. Showing typical stormy fermentation of milk by culture of anaerobic debrided from contaminated human wounds. Note the character and position of the coagulum and the gas pressing rubber cork which has been blown off by the evolution of gas. Positive test for *Bacillus elchii* 5 hours after debridement, XI 7 3, 64.

MARCH FRACTURES OF THE TIBIA AND FEMUR

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DURING combat and especially during basic training periods, the incidence of march fracture¹ has become a rather significant entity. As one reviews the literature, there is little doubt that no bone of the lower extremity is exempt from this type of injury.

An excess of current literature can be found covering march fractures of the foot, however, reports of tibial and femoral march fractures are in the minority. Our purpose in this report is to present the clinical, laboratory, and roentgenological aspects of 7 tibial march fractures and 1 femoral march fracture encountered in a 3 month period at the Station Hospital, Camp Reynolds, Greenville, Pennsylvania. It is interesting to note that this series includes the fourth reported case of an identical bilateral march fracture of the tibiae (6).

The necessity of universal recognition of tibial and femoral march fractures can be readily appreciated when one realizes the various misdiagnoses which are often "tagged" to this condition. The most common misdiagnoses are Garré's sclerosing osteomyelitis, periostitis, osteogenic sarcoma, bone syphilis, and tuberculosis of bone. Pfahler reported one insufficiency fracture of the tibia and included 2 similar cases presented by Hanson which were primarily misdiagnosed as osteogenic sarcoma. We should heed his warning as to the danger of such a diagnosis. Roberts and Voight reported a series of 15 cases of so called "pseudo-fractures" of the femur in children between the ages of 4 and 16 years which included 3 cases reported by Weaver and Francisco. These authors concluded that they were dealing with a nonsuppurative form of

osteomyelitis and proposed it as a new entity. In the light of our present knowledge, however, we are inclined to believe that what they have described are typical march fractures of the femur.

Complete clinical digestion of our 7 cases of tibial march fractures evolved the following significant findings:

1 *Body type and age incidence* Patient was usually of the tall, fair, Nordic type. The age average was 19 years and 8 months, the youngest being 19 and the oldest 22.

2 *Mode of onset* The mode of onset in every instance was sudden pain in the upper tibia followed by lameness. These symptoms always occurred during exercise such as sustained marching, double timing, or obstacle course running.

3 *Laboratory findings* The basal metabolic rates and blood counts in each case were within the accepted normal range. The serum phosphatase was within the upper limits of normal. The serum calcium was consistently low and the serum phosphorus slightly elevated. Blood Kahn tests were negative.

4 *Roentgenological aspects* The roentgenological aspect of tibial march fractures can be best outlined by indicating the constant findings that are seen on the serial roentgenograms. The diagrams in Figure 1, composites of our series of 7 tibial march fractures, clearly illustrate the stages which are present in these cases. Figure 2 illustrates the late 3d stage illustrated in these diagrams.

TREATMENT

Therapy consisted chiefly of palliative physiotherapy and cessation of all forms of forced exercise such as drills, hikes and obstacle course runs. Immobilizing casts were not applied to the affected lower extremity, and the patient was not hospitalized. Calcium therapy was not used in our cases.

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²Synonyms are shoveler's creeping exhaustion insufficiency, overload or spontaneous fractures (5). Deutschländers Krankheit, Marschger Krampf, Fusseschwulst, Marschfraktur, fracture de recrue, pied débile, pied force, pied de marche, l'enflure du pied, pied surcharge (1).

traumatic wound, the patient is placed under close observation for the development of the earliest symptoms of gas gangrene. Roentgen examinations (1) for gas in the soft tissues are done at the slightest suspicion of trouble. Serial films taken at 2 to 4 hour intervals aid in the differentiation of gas due to mechanical causes from that due to the gas bacillus. If the gas increases in amount or presents a linear spread, a diagnosis of gas gangrene can be made. In this manner a diagnosis of incipient or early gas bacillus infection can be made long before one is possible by the clinical findings alone permitting early and effective surgical treatment.

SUMMARY

The stormy fermentation of milk has been studied and found to be specific for the *Clostridium welchii* when controlled by the examination of hanging drop and stained smear preparations of the whey. We have been able to increase the speed and intensity of this reaction to such an extent that a typical reaction will occur within 5 to 10 hours or less.

The media found to be most satisfactory for this purpose can be made as follows:

A good grade of fresh pasteurized milk is boiled for 5 minutes and allowed to cool in a refrigerator for 8 to 12 hours. The supernatant cream is re-

moved by siphonage and the remaining milk is placed in culture tubes, 6 to 9 cubic centimeters per tube being used. Sterilization is accomplished by heating the milk in a dry oven on 3 successive days at 120 degrees C for 30 minutes. Indicators, strips of tery pipe iron, and enriching substances are not used. The tubes of media are kept in the refrigerator close to the operating room so that they are readily available at the time of operation.

The possibilities of the stormy fermentation of milk as a means of quick and accurate detection of *Clostridium welchii* in fresh accidental wounds have been explored. When pieces of tissue debrided from contaminated experimental human wounds were placed in suitable media, a typical reaction occurred in 5 to 12 hours. The method as described has been successfully used by us to detect accurately and quickly the presence of the gas bacillus in contaminated or infected accidental wounds and to aid in the early diagnosis and treatment of gas gangrene.

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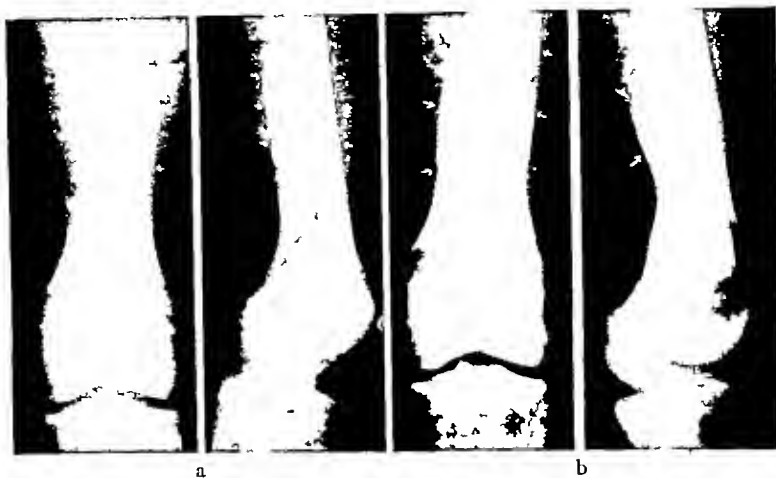


Fig 2¹ Case 2 a, Roentgenograms taken on June 16, 1943 demonstrated parallel cortical callus of a slight degree, which could have been misinterpreted as an early Ewing's tumor b, The film records of August 30, 1943 showed a marked degree of callus and bone condensation This had the appearance of sclerosing osteomyelitis

¹ The roentgenograms reproduced in this paper were made in the photographic department at the U S Army Medical Museum Washington D C The negative numbers are 76523 76527 76528 76529 76531 76533

in the lower left thigh on May 19, 1943, while marching during training maneuvers in Texas This pain became progressively worse and on the following day he was unable to get out of bed He was excused from all activity during the next 3 days

Roentgenograms of the left femur, which were taken upon return to his regular station in Texas, were declared negative (It may be stressed at this point that these micro fractures are not always

visible on early roentgenograms and the x-ray diagnosis of a march fracture cannot be made until a subsequent roentgenogram reveals a slight degree of periosteal callus)

Patient continued to have pain in the lower left thigh upon his arrival at Camp Reynolds, Pennsylvania, on June 16, 1943 Roentgenograms of the left femur taken on that day and on August 20, 1943, are presented in Figure 2 The x-ray diagnosis of a left femoral march fracture was rendered

This patient was placed on limited duty immediately and received palliative physiotherapy He was symptom free by the end of July and was placed on full duty

SUMMARY

1 A series of 7 tibial march fractures and 1 femoral march fracture are reported

2 As far as we could determine from perusal of the literature our case of a bilateral march fracture of the tibiae was the fourth of its kind to be reported More of these cases would be discovered, we believe, if comparison roentgenograms of both tibiae in suspected march fractures were made

3 The site of fracture, symptoms, and laboratory findings were found to be constant

4 The application of stage x-ray criteria would prevent unwarranted misdiagnoses such as Garré's sclerosing osteomyelitis, periostitis, osteogenic sarcoma, Ewing's sarcoma,



Fig 3 Roentgenograms illustrating a tibial march fracture in the late third stage Note the cortical callus and the bone condensation along the radiolucent fracture line Its likeness to an osteogenic sarcoma is striking

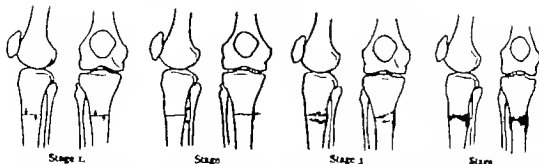


Fig. Stage 1. Time seen in the first week following the sustained march fracture. X-ray criteria: A fine horizontal fracture line is seen through the upper shaft of the tibia, about centimeters from the knee joint.

Stage 2. Time seen in the second week following the sustained march fracture. X-ray criteria: A very slight amount of callus is seen at the mediodistal cortical fracture site. The callus is first seen in this position because it is the point of greatest slight bearing stress. The fibula splits at the lateral fracture site which probably accounts for the lack of callus at this point.

Stage 3. Time seen in the third week following the sustained march fracture. X-ray criteria: A band of bone condensation is seen at the fracture site and bone absorption is immediate fracture line. Parallel cortical callus present at mediodistal cortical fracture site. Callus is sometimes seen at the lateral fracture site during this stage.

Stage 4. Time seen in the fourth week up to the twelfth week following the sustained march fracture. X-ray criteria: Cortical callus and bone condensation is increasing. Fracture line has disappeared. After the twelfth week the callus begins to absorb.

THE MECHANICS OF MARCH FRACTURE FORMATION

Ingersoll, in his excellent paper *Ice Skaters Fracture a Form of Fatigue Fracture* (fatigue fractures of the lower fibula) pointed out that a rhythmical mechanical stress at the point of greatest bone bending was the salient factor in the production of this type of fracture. In reference to fatigue fractures (march fractures) he stated: "It has been shown that such lesions tend to occur at the site of greatest bending of bone and this is determined by the forces acting upon it. In summarizing this type of fracture Ingersoll reiterated: 'Ice skaters fracture belongs in the group of fractures occurring insensibly in seemingly normal bones and resulting from the summation of microtraumas due to repeated mechanical injury.' These principles of Ingersoll can be aptly applied to the mechanics of tibial and femoral march fracture formation. The rhythmical mechanical stress was the alternate thrust of the body weight down each leg during each step. The tibia and the femur were rhythmically bent anterolaterally with each step and the microtraumas occurred at the sites of greatest bone bending which in this instance was at the upper shaft of the tibia and the lower shaft of the femur. When the saturation point of microtraumas was reached usually after sustained marches,

a complete fracture in the tibia or femur occurred.

REPORT OF CASES

CASE 1: L. M., age 19 years, an air cadet at Allegheny College, Meadville, Pennsylvania, presented himself at the orthopedic clinic at Camp Reynolds, Pennsylvania, on July 7, 1943. The patient stated that on July 7, 1943, during a 3 mile trot he experienced sharp pain in the upper left leg which became worse the following morning. Pain continued in the location but the cadet continued his duties. Several days later he experienced pain in the upper right leg after 300 yard run at moderate speed.

Röntgenograms taken on July 7, 1943, demonstrated slight degree of periosteal callus at the medial cortex of both tibiae about centimeters down from the knee joint. Careful scrutiny of these roentgenograms revealed fine transverse fracture lines extending through the full thickness of both tibiae at the level of the callus. The diagnosis of bilateral tibial march fractures was rendered and the patient was placed on a restricted exercise regimen plus palliative physiotherapy. Serial roentgenograms taken at weekly intervals revealed healing of the fractures which conformed to the stages illustrated in Figure 1.

On October 2, 1943, that patient was symptomatic and complete healing of the fractures had taken place. Full duty was permitted at this time.

Laboratory findings were consistent with those described in the clinical discussion.

CASE 2: J. C., age 19 years, Infantryman, was first seen in the orthopedic clinic at Camp Reynolds, Pennsylvania on June 6, 1943, at which time he was complaining of dull pain in the lower left thigh. He stated that he experienced a sudden sharp pain

VARIATIONS OF THE FEMALE SACRUM

Their Significance in Continuous Caudal Anesthesia

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THE ingenious method of continuous caudal anesthesia was introduced into the field of obstetrics by Hingson and Edwards in January, 1942 (4). Since this date numerous reports have acclaimed its success, and cumulative experience would seem to indicate that this procedure constitutes a very definite advancement in the management of labor and delivery (2). The administration of continuous caudal anesthesia may present at least one technical difficulty: the insertion of a malleable needle through the sacral hiatus into the sacral canal. The increasing application of this method of anesthesia, both in obstetrics and in general surgical procedures, makes it exceedingly important for the clinician to have a working knowledge of the anatomical conformation and of the more common structural modifications of the sacrum in its mid-dorsal region and especially of the sacral hiatus.

It is the purpose of this paper to record and depict certain anatomical features and structural variations of the female sacrum, not only that some of the isolated past failures in the administration of continuous caudal anesthesia may be explained but more particularly that they may be prevented in the future. Observations and measurements were made on the sacra of 674 white and negro females. Of the bones studied 328 are a part of the Terry Anatomical Collection (Washington University) and 346 a part of the Todd Anatomical Collection (Western Reserve University)¹ whose means of documentation and method of preparation have been described (1, 8).

OBSERVATIONS

The hiatus canalis sacralis may be defined as the termination of the sacral canal. It lies between the sacral cornua where the laminae of the fourth and fifth sacral vertebrae are incomplete. Thus, in viewing the sacral hiatus from its dorsal aspect it presents usually a somewhat triangular outline with the apex extending cephalad to the

level of the lower third of the body of the fourth sacral vertebra and the base caudad to the level of the middle of the body of the fifth sacral vertebra. However, the hiatus of the sacral canal is variable in extent and form.

Certain dimensions obtained on the present series serve to provide a concept of the general configuration of the hiatus. The mean width of the base of the hiatus of the sacral canal is 16 millimeters. There is a range from 7 millimeters to 28 millimeters or a total variation of 21 millimeters. The length of the hiatus from the base to the apex has a mean of 19 millimeters and varies from 0 millimeters to 66 millimeters. A sacrum with a typical hiatus canalis sacralis is shown in Figure 1a.

The anteroposterior diameter of the sacral canal at the level of the apex of the hiatus is on the average 5.3 millimeters with a range from 0 millimeters to 16 millimeters. In 55 per cent of the series this diameter was 2 millimeters or less (compare Figs. 1b and 1ob).

The apex of the hiatus is classically described as occurring at the level of the lower third of the body of the fourth sacral vertebra. In this series, however, it is located at this level in only 35 per cent. In 20 per cent of the cases the apex is found at various points below this region and in the extreme cases extends as far caudad as the lower border of the body of the fifth sacral vertebra. In the remaining 45 per cent the apex lies at planes cephalad to the lower third of the body of the fourth sacral vertebra, the highest level is at the lower third of the body of the second sacral vertebra or at the union of the bodies of the second and third sacral vertebrae (Fig. 2).

Variations in the structure of the dorsal wall of the sacral canal are numerous. It may be open throughout its entire length and 2 examples of that type are found in the Western Reserve University series. However, sacra are frequently seen in which the superior extent of the dorsal wall of the canal does not extend cephalad as far as the level of the inferior border of the body of the first sacral vertebra. This results in an increased distance between the laminae of the fifth lumbar and the bony dorsal wall of the sacral canal and a reduced distance between the supe-

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¹Dr. Normand E. Hoerr, professor of anatomy, Western Reserve University, kindly granted us the privilege of using the Todd skeletal collection.

bone syphilis of the tibia, and tuberculosis of bone.

5 The mechanics producing these types of march fractures are discussed

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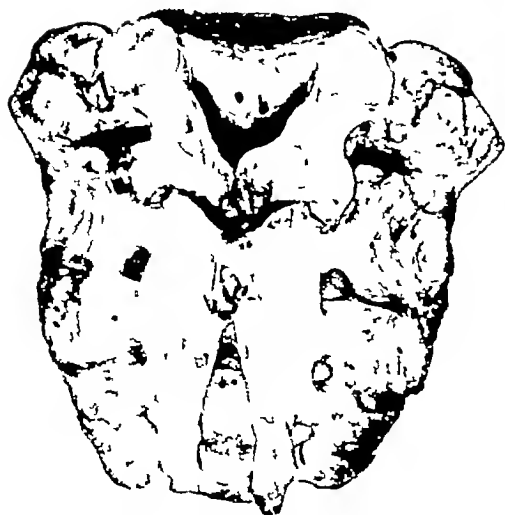


Fig 3 WU 822 A long hiatus, an aperture between the laminae of the first and second sacral vertebrae, and low lying laminae of the first sacral vertebra

dorsal wall of the sacral canal inferiorly (Fig 9a), the lumen is unaffected (Fig 9b) but the normally palpable landmarks are masked. This variation is pronounced in only one bone of the series.

DISCUSSION

In order to provide a basis for certain deductions which may be drawn from the main anatomical features and structural variations that have been described, it is advantageous to review the configuration of the average hiatus of the sacral canal (Fig 1). Among the 674 female sacra considered the typical hiatus canalis sacralis is 16 millimeters wide at the base and has a height of 19 millimeters; the apex lies at the level of the lower one-third of the body of the fourth sacral vertebra. Of these features the one most pertinent to the problem of caudal anesthesia is the height of the hiatus, this is obviously the determining factor of the level of the apex in relation to the bodies of the vertebrae. A long hiatus essentially reduces the distance between its apex and the inferior limit of the subarachnoid space (Figs 2, 3, and 6). Like dimensions may be found in hiatuses of varied contour. Thompson, in a paper entitled, "An Anatomical and Experimental Study of Sacral Anesthesia" included photographs depicting the various shapes of the hiatus—triangular, horseshoe, curve irregular, and staple—which he encountered in 38 sacra present in the anatomical laboratory of the University of Texas at the time of his study. The



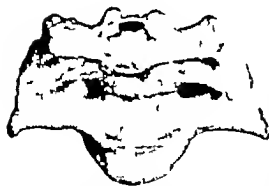
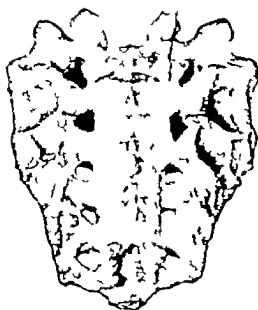
Fig 4 WU 562 Deficient development of the laminae and spines of the first and second sacral vertebrae

sacra of the present series also present a variety of contours but no variation in outline was encountered which could be construed as important in the technique of continuous caudal anesthesia.

Although the sacral hiatus may vary in extent and form without obstructing the entrance of a needle, the anteroposterior diameter of the sacral



Fig 5 WU 1160 Bilateral apertures in dorsal wall of sacral canal



b

Fig. W U 5 R 2. Hiatu canal sacra of typical dimensions b, Sacral canal of average anteroposterior character at the apex of the hiatus

rior limit of the dorsal wall of the canal and its hiatus. Such a condition may be the result of low-lying laminae of the first sacral vertebra (Fig. 3) or of deficient development of the laminae of the first or even of several of the superior sacral vertebrae (Fig. 4). In some cases the dorsal wall of the sacral canal presents a deficiency somewhere between its superior and inferior limits; this deficiency may be unilateral, bilateral, or found in the midline or it may be

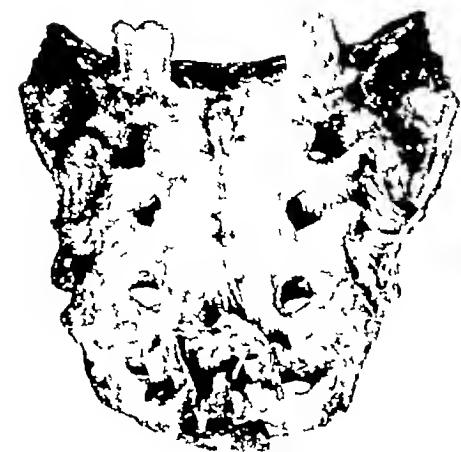
Fig. W U 312 R. A long hiatus in which the apex reaches the level of the union of the bodies of the second and third sacral vertebrae

serialized as a result of deficiency of development and subsequent union of the laminae and spines of adjacent vertebrae (Figs. 5, 6). The distance from the apex of the hiatus to such apertures or to low-lying laminae was noted. It is 70 millimeters or less in 1 per cent (148 sacra), 50 millimeters or less in 10 per cent (69 sacra), and 30 millimeters or less in 1 per cent (13 sacra).

The lumen of the sacral canal or the hiatus itself may be obliterated or partially blocked by at least two types of variation which are of opposite character. One type gives the appearance of a transverse fold in the dorsal wall of the canal and is associated with forward projection of the body of the vertebra just cephalad to the level of the compression (Fig. 7). This condition in the dorsal wall may and usually does completely obliterate the lumen of the canal where it occurs. Ten sacra of this series present such a fold or compression; in 7 it extends between the second pair of posterior sacral foramina and in the remainder it lies between the third pair of posterior sacral foramina. The second type of variation is the result of backward or dorsolateral projection of the body of the vertebra into the sacral hiatus or canal (Fig. 8). It usually occurs either in a markedly curved sacrum and the projection is a constituent of the curve or in a straight sacrum with the first coccygeal vertebra fixed at an angle approaching 90 degrees.

Lastly there may be present an overgrowth of bone obliterating the hiatus and extending the

(The photographs for this figure and for microfilm for x-rays were made by Mr. M. B. Klammer of the Department of Anatomy.)



a



b

Fig 9 W U 1078 a, Bony overgrowth obliterating the hiatus and extending the dorsal wall of the canal caudally b, Anteroposterior diameter of the sacral canal unaffected by the bony overgrowth



a



b

Fig 10 W U 1526 a, The hiatus canalis sacralis viewed dorsally exhibits no unusual features b, The sacral canal viewed through the hiatus presents at its caudal limit an anteroposterior diameter of only 1 millimeter

19 gauge needle the hiatus may be completely blocked or so reduced as to make the insertion of the needle impossible. One such example consists of a dorsal protrusion of the body of a lower sacral vertebra into the hiatus or canal (Fig 8). Also, there may exist a condition simulating a fold which completely occludes the canal (Fig 7). Certain features of this latter variation are suggestive of spondylolisthesis, which is usually described as occurring in the lumbar region of the column. This variation is present in 10 of the specimens, a small incidence, but nevertheless, a significant clinical feature when encountered.

The dorsal wall of the sacral canal is not infrequently open to a greater degree than is normally anticipated. Several general types of dorsal wall agenesis are described in this paper and may be listed as superior or inferior laminar deficiencies

and unilateral, bilateral, or midline apertures (Figs 3, 4, 5, and 6). "The more common formations and anomalies of the sacrum" depicted by Southworth, Hingson, and Edwards (7) in a series of drawings made from the skeletal collection in the Museum of Anatomy at Jefferson Medical College present examples of dorsal wall deficiencies. Hingson and Edwards have included similar illustrations in their article entitled "Comprehensive Review of Continuous Caudal Analgesia for Anesthetists" (6).

The importance of dorsal wall agenesis is directly related to the fact that after the special caudal needle pierces the superficial posterior sacrococcygeal ligament it is of necessity "depressed almost to a level with the body plane, and its point directed upward exactly in the midline, following the axis of the canal for a distance of $1\frac{1}{2}$



Fig. 6 W.U. 305. Apertures in the midline of the dorsal wall of the sacral canal between laminae of the first and second sacral vertebrae and between laminae of the second and third sacral vertebrae also, long hiatus.

canal at the level of the apex of the hiatus is of prime importance in the technique of the administration of caudal anesthesia. Indeed, it may be the determining factor for entrance of a needle into the sacral canal after it has pierced the superficial posterior sacrotuberous ligament. The mean diameter of this aperture is 5.3 millimeters (Fig. 7b). In 5 bones the dorsal and ventral bony



Fig. 7 W.U. 306. A condition simulating transverse fold in the dorsal wall of the sacral canal is indicated.



Fig. 8 W.U. 312. a, Protrusion of the body of the fifth sacral vertebra dorsward into the sacral hiatus, the first coccygeal vertebra is fused to the fifth sacral at an angle approaching ninety degrees. b, Shortened anteroposterior diameter of the sacral canal at the level of the apex of the hiatus, the result of the dorsward protruding vertebral body.

walls of the sacral canal are completely free at the level of the apex of the hiatus in 30 bones (55 per cent) the measurement was 2 millimeters or less (Fig. 9). Furthermore in the recent or living state this diameter may be appreciably decreased by the presence of the periosteum and the posterior longitudinal ligament. The needle which is recommended as most suitable for this procedure is No. 8 or 9 gauge stainless steel malleable needle. It becomes evident therefore when all of these factors are taken into consideration that on a purely mathematical basis it may be extremely difficult or indeed impossible to insert even a No. 19 gauge needle into the canal in a small percentage of patients.

In those sacra with canal of such diameter that permit with ease the introduction of No. 18 or

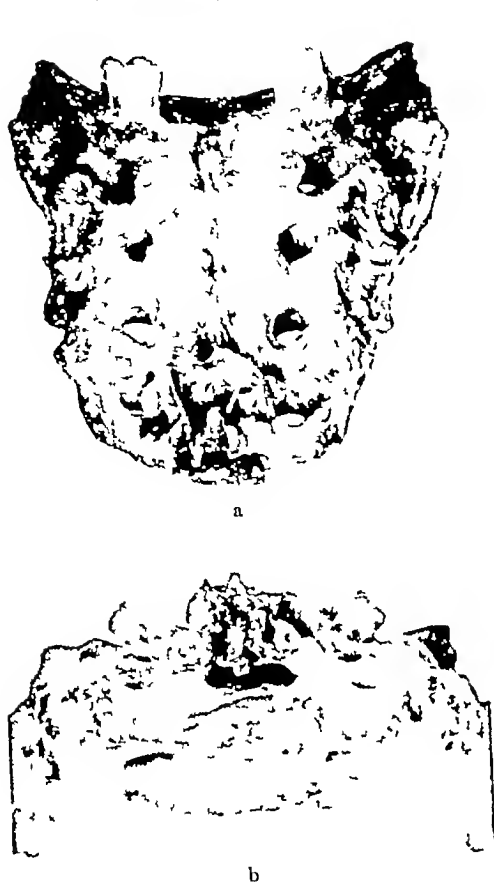


Fig 9 W U 1078 a, Bony overgrowth obliterating the hiatus and extending the dorsal wall of the canal caudally b, Anteroposterior diameter of the sacral canal unaffected by the bony overgrowth



Fig 10 W U 1526 a, The hiatus canalis sacralis viewed dorsally exhibits no unusual features b, The sacral canal viewed through the hiatus presents at its caudal limit an anteroposterior diameter of only 1 millimeter

19 gauge needle the hiatus may be completely blocked or so reduced as to make the insertion of the needle impossible. One such example consists of a dorsal protrusion of the body of a lower sacral vertebra into the hiatus or canal (Fig 8). Also, there may exist a condition simulating a fold which completely occludes the canal (Fig 7). Certain features of this latter variation are suggestive of spondylolisthesis, which is usually described as occurring in the lumbar region of the column. This variation is present in 10 of the specimens, a small incidence, but nevertheless, a significant clinical feature when encountered.

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1.2 inches. (4) The presence of any unexpected aperture may permit the point of a dorsally directed needle to escape the canal and thus result in the subcutaneous deposition of the anesthetic agent (Fig. 6). Since "The needle should be inserted within the canal for a distance of about 5 to 7 cm. (3) the distance from the apex of the hiatus canalis sacralis to a superior deficiency or unilateral, bilateral or midline aperture is of real clinical significance. This distance is 7 centimeters or less in 2 per cent of the sacra included in this study. In 1 per cent of the sacra this distance is 2 centimeters or less (Fig. 5).

In the administration of continuous caudal anesthesia "The tip of the coccyx is palpated with the middle finger of the left hand and the thumb is used to find the U or V shaped notch indicating the sacral hiatus between the sacral cornua. This is usually about $\frac{1}{2}$ or 1 inch from the tip of the coccyx. (5) The clinician must nevertheless, be well aware of the fact that the girdling anatomical features may be completely disguised or alleviated by bony overgrowths and projections. The sacrum depicted in Figure 9 well illustrates how such a growth may totally mask the hiatus although the canal may be of even greater than average diameter. Indeed in this case the anteroposterior diameter of the canal is 6 millimeters (Fig. 9b).

Numerous other minor variations might be cited which under certain circumstances could conceivably impede the introduction of the special continuous caudal anesthesia needle into the hiatus canalis sacralis. It has been the purpose of this paper however to limit the material presented and the features discussed to those factors which anatomically and statistically seemed to be of special clinical importance and thus warrant the careful consideration of the practicing obstetrician and surgeon.

ST. MARY

Variations in the anatomy of the subarachnoid region of the sacrum and their significance in the administration of continuous caudal anesthesia were studied in a series of 674 female bones.

1. In 45 per cent the hiatus canalis sacralis reached a level on the sacrum cephalad to the level of the lower third of the body of the fourth sacral vertebra. This condition reduces the distance between the highest possible point of entrance of the needle into the canal and the inferior limit of the subarachnoid space.

2. In 2 per cent deficiencies existed in the dorsal wall of the sacral canal which might permit an exit of the needle. This would result in the injection of the anesthetic agent into the surrounding soft tissues.

3. In 5.5 per cent the anteroposterior diameter of the sacral canal at the level of the apex of its hiatus was 3 millimeters or less. The insertion of a 19 gauge needle into such a canal is difficult if not impossible.

4. Other variations include obliteration of the lumen of the sacral canal and masking of the palpable landmarks in the region of its hiatus.

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THE INCIDENCE OF LIVER STONES ASSOCIATED WITH CHOLELITHIASIS AND ITS CLINICAL SIGNIFICANCE

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THE incidence of cholelithiasis in adults, as proved by various autopsy studies and examination of cadaver material, is probably between 20 and 30 per cent. Graham, Cole, Copher, and Moore, in their textbook concerning the gall bladder, placed the figure between 20 and 25 per cent of all adults. Carter, Greene and Twiss, in a more recent textbook, noted a similar figure. Mentzer reported 26.6 per cent in 633 autopsies. Hektoen and Riesman found calculi at autopsy in 25 per cent of all cadavers after the 60th year. Hansen of Norway quotes a percentage of 24.7 in 392 autopsies.

The high incidence of common duct stones in cases of cholelithiasis has been fully appreciated only during the last 15 years. In the past, continued or recurrent biliary distress following cholecystectomy has too frequently been attributed to liver dysfunction, hepatitis, cholangitis, pancreatitis, or partial injury to the common duct, when as a matter of fact it was due to a stone in the common duct. In 1928, Wilkie emphasized the frequency of common duct stones in cases of cholelithiasis by reporting 47 patients with stones in the common bile duct in a total of 256 operated upon for cholelithiasis (18 per cent). This was followed in 1930 by Clute's enlightening and interesting report that he had explored the common duct in 15 per cent of a series of cases, and had found common duct stones in 8.4 per cent. In another series, he had opened the common duct in 35 per cent of the cases, finding that the incidence of common duct stones increased correspondingly to 17.9 per cent. Lahey reported that the common duct was explored in 40 per cent of a series of patients between 1930 and 1935, and stones were found in 18 per cent. Crump, in a series of 1000 routine autopsies, reported 325 with gallstones, 78 (24 per cent) of these having stones in the biliary ducts. In my last 100 consecutive cholecystectomies, 33 common ducts were opened (33 per cent), and common duct stones were found in 17 of these (17 per cent). As one analyzes the figures of various authors, it would seem that the common duct should be explored in 20 to 40 per

cent of all cholecystectomies, and that stones will be found in about one-half of the ducts opened. In other words, in 1 of every 4 or 5 cases of cholelithiasis, stones will be found in the common duct. The usual criteria for opening the duct have been a history of jaundice, palpable stones in the common bile duct, a dilated common duct, a thickened common duct wall, small stones in the gall bladder, or thickening of the head of the pancreas.

Regardless of how frequently choledochostomies are performed or what technique is used, I believe that sooner or later every surgeon will encounter 1 or more cases in which he feels satisfied in his own mind that the common duct has been thoroughly explored and all stones and debris removed, only to find out later at a necessary secondary operation that another stone is present. There is no doubt that there are elusive stones in the common duct, especially at the lower end where at times they seem to seek a small diverticulum or pocket and avoid the exploring forceps, probe, or irrigator. Again, stones may form from minute particles of debris or precipitate in the choledochus.

However, I believe that there is another very definite source of so called recurrent or remaining common duct stones, which, as one peruses the literature, he finds is seldom mentioned. I refer to stones which are present in the liver at the time of the original operation and which, for one reason or another, become dislodged from the intrahepatic ducts following cholecystectomy, and give rise to symptoms. It is entirely plausible that some of these stones are dislodged by factors associated with opening the common duct, such as manipulation of the duct, changes in intraductal pressure, and irrigation of the duct. In other instances, it is possible that the freeing of the lower end of the common duct permits free egress of bile. Again, the time element may be the only factor.

By examination of the autopsy records of the usual hospital—be it a charity, teaching, private or clinic type of institution—one is unable to arrive at a significant or accurate conclusion as to the incidence of liver stones, for, in the routine autopsy, examination of the liver consists merely of weighing the organ and describing its appearance, color, and consistency after 3 or 4 slices are

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TABLE I.—INCIDENCE OF LIVER STONES
IN CHOLELITHIASIS

Cases of cholelithiasis	Cases of liver stones	Incidence Per cent	Author	Year re- ported	Country
Not given	Not given	1	Thudichum	186	Germany
Not given	Not given	6	Schwarz	186	Germany
73	6	8.3	Beer	1904	Germany
112	10		Miyake	1914	Japan
97		7	Hansen	1926	Norway
30		6	Beer	1923	U.S.A.
426					
		7.1			

Average of all percentages
Average including first group.

made through its substance. Until this investigation was begun, on no occasion had I seen the liver sliced thin enough that all intrahepatic ducts were opened so that any stone resting in a duct could be identified. Later however this procedure was carried out in 30 cases of cholelithiasis, and in 2 of them stones were found within the intrahepatic ducts.

In 1 of these instances, a middle aged woman from whose common duct I had removed a stone, delayed cholangiogram taken 9 days after operation had revealed a remaining common duct stone. Following the second operation, for removal of this remaining stone, the patient died. Examination of the liver by the method here described revealed stones in the ducts of the right lobe of the liver and 1 stone in a duct of the left lobe.

The other case was that of a woman who had died of a cardiovascular disturbance. Autopsy revealed many small stones in the gall bladder and a few stones as well as considerable thick debris in the common duct. This patient had given no history of jaundice but did have a long history of severe indigestion and rather sharp upper quadrant distress. Careful examination of the liver revealed a single stone in a duct of the left lobe of the liver.

The finding of liver stones in these cases in a group of 30 cases of cholelithiasis gave an incidence of 6.6 per cent. This stimulated me to attempt to confirm what seemed a fairly high incidence of liver stones. Although a rather extensive search was made in the literature for reports of liver stones, I have made no attempt to report on the subject of single cases of liver stone, but have merely attempted to find evidence to support my own figures on the incidence of such stones and to arrive at some definite conclusion which might be of clinical value in the problem of the

so called recurrent or remaining common duct stone.

According to Rusanov isolated cases of liver stones were reported in the 16th and 17th centuries. In 1863, Thudichum, quoted by Beer (1) stated in his treatise on gallstones that 5 per cent of all patients with cholelithiasis had stones in the liver. Courvoisier in 1890, collected the cases in the literature to that date, 50 in number but in his lengthy discussion of hepatolithiasis did not give the relative frequency. In 1890, Schroeder quoted by Beer (2) reported that intrahepatic concretions were present in 9 per cent of his cases. However like Thudichum, he drew his conclusions from autopsy notes and did not state the number of cases he had examined. In 1904, Beer (1, 2) reported in both American and German literature his findings of biliary pathology in 250 autopsies in which the entire liver ductal system was carefully examined for stones. Of these 250 cases, 71 had cholelithiasis, 6 with stones in the intrahepatic ductal system. In 5 of these cases, the stones are rather large and in the 6th there was considerable gravel in the liver ducts. This gives an incidence of 8.3 per cent of stones within the liver in cases of cholelithiasis. In 1913, Miyake of Japan reported on 8,400 routine autopsies. There are 257 cases of cholelithiasis which he examined thoroughly for liver stones. Of these 30 had intrahepatic duct stones, an incidence of 7.7 per cent. Miyake collected these cases from 3 different pathological-anatomic institutes. There were 191 cases of cholelithiasis from Tokyo 13 of them with liver stones 35 cases from Khokoto included 1 with liver stone 31 cases from Krasnodar with 6 cases of liver stones. Rusanov in discussing this article by Miyake, stated that liver stones were more frequent in Japan but it would seem the higher incidence depended rather upon the method and thoroughness of the search for stones. In 1923, Hansen of Norway reported on 392 autopsies 149 cases of cholelithiasis. Careful examination of the liver in these cases revealed 7 with stones in the intrahepatic ducts, an incidence of 7.2 per cent. In 1936, Rusanov thoroughly discussed the subject of liver stones in an excellent article and, as quoted before in this thesis, he stated that hepatolithiasis was of rare occurrence according to data from the pathological institutes of Russia, but again it must be emphasized that the method of examining the liver was probably inadequate. He reviewed considerable literature and, although he again reported and discussed many isolated cases in addition to 5 cases of his own, under no circumstances could one arrive at the incidence of liver stone in cases of cholelithiasis. His lengthy

article was written with the hope of arriving at some conclusion regarding the diagnosis of hepatolithiasis, the type of treatment most satisfactory, the pathological picture, and to clear up some questions on the pathogenesis of gallstone disease as a whole

In an analysis of the figures presented, we find that the average incidence of liver stones is 7.4 per cent (Table I). If we include only those figures which show the number of cholelithiasis cases with the number of cases in which liver stones were found, we have a more accurate analysis. In total, there were 456 cases of cholelithiasis with 35 cases of liver stone, an incidence of 7.6 per cent (Table I). This figure seems rather high for the incidence of liver stone in cholelithiasis, but is substantiated by the fact that each group of cases examined revealed a similar figure.

As to the source of liver stones, it is possible they are dislodged from the gall bladder into the common duct and then carried into the intrahepatic ducts, or they may form within the liver ducts themselves. If stasis, infection, and metabolic disturbances are considered as etiologic factors of stone formation within the gall bladder, the fact that fewer stones are found in the liver could be based entirely upon the fact that bile stasis is less common in the liver than in the gall bladder. That gallstones may develop in the ductal system is somewhat substantiated by the fact that Ruffanov reports a case described by Leopold in which a common duct stone was found and removed when there was a congenital absence of the gall bladder. He refers to a similar case reported by Finkelstein, and in this instance the common duct stone recurred. According to various investigators, the composition of stones found in cholecystolithiasis, choledocholithiasis, or hepatolithiasis seems to have the same variation as stones from the gall bladder.

Hepatolithiasis may be classified as follows: (1) isolated stones within the ducts, (2) ducts packed with stones, gravel or a pasty, cement-like debris, (3) stones imbedded in a cavity containing a collection of bile or pus, (4) an existing purulent cholangitis with multiple small abscesses containing stones or gravel. I have seen cases of the first 2 types.

Surgical attacks upon liver stones have been limited because of the difficulty of diagnosis as well as the technical difficulty of the surgical approach. I have reviewed many cholangiograms but have never seen one revealing a stone within the intrahepatic ducts, although I have heard this described. On a number of occasions, I have felt that evidence was sufficient to prove that the

stones revealed in the common duct by delayed cholangiograms following careful choledochostomy had their origin in the liver. The most significant example of this was one of several cases previously described (3, 4) in a discussion of nonoperative management of remaining common duct stones. The delayed cholangiogram revealed 11 common duct stones. At the time of operation on this thin patient, the common duct was easily accessible, it had been opened and thoroughly explored but no stones were found. Upon examination of the cholangiogram on the 8th postoperative day, it could only be concluded that this number of stones could not have been missed at operation but had come down from the liver. In the article referred to, the 3 day biliary flush is advocated as a means of removing common duct stones and debris has succeeded in 25 per cent of such cases.

From previous studies on increasing the flow of bile and raising intraductal pressure (5), it is believed that one can safely assume the same measures would flush out stones and debris from the intrahepatic ducts into the common duct. It might be suggested that all patients subjected to cholecystectomy or any type of biliary tract operation should have the following 3-day biliary flush several days preceding operation in the hope that any intrahepatic stones would be forced into the common duct where they would be accessible at the time of cholecystectomy. Thus a secondary operation for a stone which had descended later might be avoided.

THREE DAY BILIARY FLUSH REGIMEN

1st day

1. Decholin or procholol—3 tablets 3 times a day and at bedtime

2. Nitroglycerin, grains 1/100, 3 times a day before meals

3. Magnesium sulfate, 2 drams before breakfast

4. Pure cream, 1 ounce before evening meal and at bedtime.

2nd day

1. Decholin or procholol—3 tablets 3 times a day and at bedtime

2. Atropine, grains 1/100, dissolved in a little water, 3 times a day before meals

3. Magnesium sulfate, 2 drams before breakfast.

4. Pure cream, 1 ounce before evening meal and at bedtime

3rd day

1. Decholin or procholol—3 tablets 3 times a day and at bedtime

2. Nitroglycerin, grains 1/100, 3 times a day before meals.

3. Magnesium sulfate, 2 drams before breakfast

4. Pure cream, 1 ounce before evening meal and at bedtime

Animal investigation has not been carried out to prove this supposition, but removal of common

duct stones and debris by this method has frequently been demonstrated. Likewise the routine postoperative use of the 3-day biliary flush in all cases of cholecystectomy has certainly resulted in a smaller number of postoperative biliary syndromes and lends support to the contention that the ductal system can be flushed out. As a routine measure the biliary flush is given on about the 8th postoperative day and is repeated 2 weeks later.

SUMMARY

From investigation and from available figures, it would appear that liver stones are present in approximately 7 per cent of 11 cases of cholelithiasis, this probably being the source of a certain number of recurrent or remaining common duct stones. It is suggested that the 3-day biliary flush be given to all patients before any biliary tract operation in the hope of flushing these liver stones into the common duct where they will be accessible at the first operation, thereby avoiding a second

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FRACTURED PELVIS COMPLICATED BY GANGRENE OF EXTREMITY—AMPUTATION UNDER REFRIGERATION ANESTHESIA

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RARELY is the complication of gangrene of the lower extremity following fractures of the pelvis mentioned in the literature on this subject. The fact that one of the authors has had the unusual experience of helping in the management of 2 such cases within the period of approximately 1 year justifies this report. The additional fact that refrigeration of the affected extremities was utilized for a considerable period prior to amputations and that eventually the amputations were performed under refrigeration anesthesia should arouse further interest in these 2 cases.

When one considers the intimate relationship of the iliac and femoral vessels to the bones of the pelvis it is almost inexplicable that injuries to these vessels and their branches have not been noted and reported more frequently. The same is true of the large nerve trunks which traverse the pelvis, injuries to which are seldom mentioned in the literature. Most authors, in dealing with complications associated with fractured pelvis, dwell upon injuries to the bladder, urethra, and rectum and their sequelae. The fact that the blood vessels, especially the smaller branches, are very frequently injured, is borne out by the presence of hematomas of varying sizes within and without the fractured pelvis. However the collateral circulation to the lower extremities is so rich about the pelvic girdle that rarely does interference to circulation manifest itself beyond a slight pallor or numbness in the extremity. Most of us have witnessed this phenomenon without thinking of or fearing gangrene. But when a large hematoma indicative of damage to the branches comprising this collateral circulation is combined with thrombosis of the external iliac or femoral arteries, then gangrene of a major portion of the lower extremity is extremely imminent.

In the first instance, with only pallor and numbness present, one should use every available means to conserve the part until the circulation is re-established. Whether this can best be accomplished by the time honored methods of wrapping the extremity in cotton-wool and applying heat, or by the newer method of slowing the demands of

metabolism by refrigerating the part, will be a mooted question until time and experience have proved or disproved the value of the latter method. When the circulation to the lower extremity is so damaged that gangrene is inevitable, prevention of the moist, infected type of gangrene until the line of demarcation is established is our chief concern. Here refrigeration is far more efficacious than heat. The refrigerated extremity, provided refrigeration is adequate, soon passes into a state of hibernation. All metabolic processes, including the demand of the tissues for oxygen and blood supply, are in abeyance. The development of infection and the liquefaction of dead tissues with their accompanying toxins are likewise held in abeyance. If, as was true in one of our cases, the patient's general condition is such as to make early amputation inadvisable and dangerous, this period of hibernation can be prolonged until the patient's condition warrants amputation.

Fractures of the pelvis, when uncomplicated, are correctly considered the simplest type of major fractures to treat. When complicated they often present the most serious emergency taxing the surgeon's judgment and ability to the limit and not infrequently end fatally. In some eight hundred cases collected from the literature where mortality rates were mentioned, the latter varied from 8 per cent to 17.7 per cent. In 108 cases treated by the senior author, from 1922 to 1942, 9 deaths occurred from complications. Three of these fractured pelvises were associated with skull fractures. The fact that the fracture *per se* is simple to treat must not lull the surgeon into complacency lest one of these serious complications be overlooked.

In a review of 5 recent textbooks on fractures, all the authors stress the complications of ruptured bladder, urethra, and rectum. Most of them refer to the possibility of intra-abdominal injuries. Scudder, and Key and Conwell each mentions the complication of fatal hemorrhage from injuries to the great vessels unless these can be exposed and ligated. Not one of these 5 authors mentions thrombosis of the external iliac

or femoral arteries followed by gangrene and the possibility of amputation.

One of us (Tanehill) made a comprehensive review of the literature on the subject of fractured pelvis covering the period from 1878 to 1943 and thereby collected 3,083 cases. In only 13 cases were injuries to the external iliac or femoral vessels mentioned. Three of these were described as lacerations of the external iliac artery, 2 as lacerations of the external iliac vein, 1 as a laceration of the femoral vein, 1 as an injury to the external iliac and femoral vessels followed by gangrene and amputation, 3 as a thrombus of the external iliac artery, 1 of these followed by gangrene and amputation, 2 as a thrombus of the femoral artery, and 1 as a gangrene of the lower extremity. Eight of these 13 patients died from the above complications. It is noteworthy that in 3,083 cases collected from the literature only 3 cases of gangrene of the lower extremity were listed and in only 2 of these cases were patients subjected to amputation, with 1 of these recovering.

Newell reports on 4 cases of fractured pelvis, of which was complicated by an injury to the external iliac artery and 1 by the fractured horizontal ramus injuring the external iliac artery. In the latter case gangrene developed in the corresponding lower extremity necessitating amputation above the knee. This patient recovered.

Lucas describes 3 cases of fractured pelvis, with lacerations of the external iliac vein and with laceration of the external iliac artery. All died.

Bacon describes hemorrhage as occurring in 6 cases from tearing of the soft parts. One of these cases had a laceration of the femoral vein, the patient dying of hemorrhage.

Browne mentions a case in which the fractured superior ramus of the pubis had torn off the inferior epigastric artery at its origin from the external iliac artery. The artery was ligated but death followed 4 hours later from shock.

Moritz had 1 case in which the femoral vein was lacerated by a spicule of bone from the pubic crest. The vein was repaired by lateral suture with recovery of the patient.

Grandy reports 1 death from laceration of the external iliac artery complicating a fractured pelvis.

Magruder reports a case of oblique fracture of the right ischium with overlapping of the fragments with fracture through the right sacroiliac joint. The right lower extremity became cold and sensation was lost. There was no pulsation in the femoral, popliteal, or posterior tibial arter-

ies. No operative intervention was attempted. Gangrene developed and the patient died 18 days after the injury. The autopsy revealed the anterior crural nerve and the external iliac artery caught between fractured fragments and completely severed. There was a thrombus in the external iliac artery extending almost up to a common iliac.

Glen describes a fractured superior ramus of the pubis which occluded the external iliac artery by forcing it against the inguinal ligament. The latter was divided at operation and circulation thereby restored. However, the patient died in the third day of uremia.

In an article entitled "Obstruction of Arteries due to Injury" T. Bryant lists 3 cases of thrombosis of the external iliac artery associated with pelvic fracture, and in addition thrombosis of the external iliac and femoral artery due to a severe contusion without fracture. One of these, a male, aged 33 years, was seen 2 weeks following injury sustained in a fall from a horse. There was a swelling in the right groin and the right leg was cold and numb. There was no pulsation in the external iliac, femoral or popliteal arteries. The leg was wrapped in cotton-wool and elevated. In 6 weeks the tibial vessels were felt pulsating and in another 3 weeks the superficial femoral artery was evidently open. After convalescence no pulsation was ever detected in the external iliac or femoral arteries. In the other 2 cases of pelvic fracture gangrene developed in the lower extremity, 1 was amputated and died 21 days later, and the other died on the 31st day without amputation. Autopsies in both instances revealed the thrombosed external iliac arteries.

In a paper, not yet published, presented before the American Academy of Orthopedic Surgeons in 1933 one of the authors (Mock) described a case of fractured pelvis with tearing of the femoral artery followed by severe hemorrhage into the thigh. This patient was in such critical condition when seen that an emergency bedside operation was performed and the femoral artery ligated. Before a blood transfusion could be administered the patient died. Mock also described a case of fractured pelvis in an elderly woman with a large dissecting hematoma down the right thigh. The hematoma was evacuated. Gangrene of the skin and fascia of the entire circumference of the lower third of the thigh, except for an area of 3 inches in width on the posterior surface, and gangrene of the skin over 60 per cent of the circumference of the knee developed. The gangrenous tissue over these areas was dissected away. The wounds were eventually closed by skin grafting.

To these 2 reported cases of gangrene of the lower extremity treated by amputation, which were found in the literature, the authors wish to add their 2 cases

CASE REPORTS

CASE 1 B K., aged 21 years, was caught in a milling machine and the right side of his pelvis was severely fractured. In addition a compound fracture of the proximal ends of the radius and ulna opened wide the elbow joint. He was immediately hospitalized and hemorrhage and shock were combated by transfusion and other means. The senior author was called in consultation 36 hours after this accident occurred because a paralysis had developed in the patient's right leg. Case notes on the hospital chart indicated that patient could move his right leg during the first 24 hours, but signs of paralysis had developed during the subsequent 12 hours.

Examination of the injured parts revealed a 3 inch laceration with multiple puncture wounds over the right lower abdomen, a hand's breadth above the pubis and 3 inches inside the crest of the ilium. These wounds penetrated the skin and fascia but did not enter the abdominal cavity. The upper half of the right ilium gave a sense of crepitation and looseness. There was a marked swelling suggesting a retroperitoneal hematoma inside the crest of the ilium as well as under the gluteal muscles. The right lower extremity seemed completely paralyzed. There was a definite foot-drop. Anesthesia of the entire right lower extremity was present, and temperature, tactile, and position sense were lost. Patellar and Achilles reflexes, present in the left leg, were completely absent in the right. The leg was not cold or blanched, and at this time no thought of a circulatory disturbance was considered. Rather, the consultant's entire attention was centered upon the possibility of a nerve injury either from fragments of the fractured pelvis or from an injury to the spine.

A portable x ray examination of the pelvis, made a few hours prior to this consultation, showed the upper half of the entire right ilium completely fractured with numerous comminuted fractures through both the anterior and posterior fragments of the ilium. The lower end of the main fracture ended just above the acetabulum. Two fragments of bone were broken completely from the ilium and were pushed downward behind the greater trochanter.

The right arm was markedly swollen from the axilla to the wrist. There were severe lacerations about the elbow with evidence of multiple fractures which were shown by the portable x ray. No further reference will be made to the arm except to mention that the presence of this severe upper extremity injury probably slowed down the treatment of the pelvic condition and added greatly to patient's extremely critical condition during the first week. The arm was saved but with much deformity at the elbow.

Shock and hemorrhage had been and were still the most alarming features present. These two conditions definitely contraindicated any radical surgery at the time of this consultation. Even in considering surgery, the severely damaged arm seemed to be the chief point of attack.

On June 27, or 9 days following consultation, the author was again called to see this patient. During the interval he had developed marked infection in both the compound fractures of the arm and in the lower abdominal wounds. Drainage had been established at both sites. The paralysis in the right leg had persisted. Two days prior to this second consultation, a slight discoloration of the right great toe was noted for the first time. The following day this bluish discoloration had involved half of the foot.

Examination showed that pulsation over the femoral and popliteal arteries was completely absent although this was said to have been present 3 days previously. Beginning gangrene of the lower extremity was evident. A fluctuating mass extended from the gluteal crease up over the entire right side of the pelvis and onto the abdomen. An immediate operation for the evacuation of this infected hematoma and the removal of the loose fragments of the ilium behind the greater trochanter was recommended, and the consultant was asked to perform the operation. It was hoped that by taking the pressure off of the collateral circulation there was a possibility that this might re-establish itself and thus check the progress of the gangrene. There was also a chance that the femoral artery had become plugged with a thrombus quite recently and this might be removed.

Operation. Under general anesthesia an incision was made over the right hip and a quart and a half to two quarts of old bloodclots and pus were evacuated. The cavity involved all of the gluteal region and extended upward along the surface of the fractured ilium onto the abdomen. This cavity was readily connected with the infected cavity at the site of the abdominal injury. Two large fragments of the ilium were displaced downward, one behind the hip joint and the other between the hip joint and the greater tuberosity. These fragments were removed. Following this procedure a second incision was made over the femoral artery and vein. Both vessels were completely thrombosed. The thrombi were organized and considerable liquefaction of the tissues about the vessels was present.

In an effort to localize the gangrene to the foot or lower extremity ice bags were packed around the foot and up to the middle third of the leg in order to refrigerate the part. No tourniquet was applied. This was one of our earliest cases of refrigeration and the ice bags were not kept filled and constantly in close apposition to the part, as has been true with subsequent cases. The black toes and bluish foot remained the same but the ankle and lower third of the leg developed a pinkish appearance, and at no time did the gangrene seem to spread and neither did a moist gangrene or infection develop. Pulsation, however, never returned in the popliteal artery or in the vessels of the lower extremity. Meanwhile, the patient's condition, the result of the extensive infection at the hip, improved. His temperature became normal. After 2 weeks amputation in the middle third of the leg was deemed advisable.

A soft rubber tube was placed about the leg, just below the knee, as a tourniquet, after the site had been refrigerated by ice bags for 1 hour to anesthetize the part. A rubber sheet was then tied about the thigh 4 inches above the tourniquet and was wrapped about the entire lower extremity as a trough. This trough was filled with two and one half buckets of cracked ice, making positive that the ice extended above the tourniquet and surrounded the limb, including the foot. After 2½ hours of refrigeration, with tourniquet in place, amputation 6 inches below the knee was performed. No other anesthetic whatsoever, other than a drink of whisky, was used. The muscles and the fat at the site of amputation had a healthy red appearance, except for a darkened area in the gastrocnemius muscle which resembled spoiled meat, similar to that seen in a leg of beef hung in the refrigerator. Refrigeration of the stump, without tourniquet, was continued for only 2 days. A longer period of refrigeration might have avoided the subsequent development. This area in the gastrocnemius muscle broke down and developed a low-grade infection, and the gangrene spread through the posterior surface of the stump in spite of renewed refrigeration. Two weeks later, again under refrigeration anes-

thigh, second amputation was performed through the thigh just above the knee. This stump healed rapidly and the patient's convalescence was uneventful.

CASE 2. F. S., male, aged 5 years, on February 6, 1915, sustained crushing injury of the head, chest, and pelvis, when he was caught between the wheels of railroad crane and loading platform. He was admitted to St. Luke Hospital on the service of Drs. Chivers and Tunnell, about 1 hour after injury in state of shock, temperature, 95 degrees; pulse, 60; respiration, 30; blood pressure, 90/60. The pulse was weak and thready and the patient was very dyspneic.

This patient showed dramatic picture of traumatic asphyxia. His face, neck, upper chest, and arms were very cyanotic subconjunctival hemorrhages. His edema of the conjunctiva were present, and ecchymotic areas and petechial hemorrhages soon developed over the head and neck.

Pressure over the iliac crest caused severe pain in both groins. The lower abdomen was rigid. The patient was able to move both lower extremities, but was unable to walk. Blood was noted coming from the urethra. A diagnosis of ruptured urethra in the presence of possible pelvic fracture was made. Dr. Harry Colver passed catheter with considerable difficulty and it was left indwelling for weeks when the lesion was healed.

Patient was placed in an oxygen tent, morphine as administered for the pain, and 50 cubic centimeters of plasma and 50 cubic centimeters of serum are given, following which the blood pressure rose to 95/70 and in few hours to 100/80.

Portable x-ray plates of the pelvis revealed fracture of the left ischium at the junction of the horizontal and vertical canal fracture through the left ischium at its junction with the sacrotuberosus, comminuted fracture involving the horizontal rami of the right ischium, and fracture of the right pubis at its junction with the sacrotuberosus, with the fragments displaced slightly left and back upward, causing definite deformity of the pelvic inlet.

During the next 24 hours the patient was fairly comfortable. He was still in an oxygen tent because of the marked cyanosis described. He then began to complain of pain in the right leg. All ability to move the leg was lost. The limb at this time was cold and blanched. Pulsion in the dorsal pedal, posterior tibial, popliteal, and femoral arteries was absent. Thrombosis of the right external iliac and femoral arteries was suspected.

It was at this point that the senior author was called in consultation. Unquestionably gangrene of this entire lower extremity was inevitable unless some collateral circulation developed before such catastrophe occurred. Refrigeration of the entire extremity was suggested as means of lowering the demands of metabolism in this limb, of holding off most gangrene and infection in abeyance, and of giving time for the formation of collateral circulation if the same was possible. At any rate, we could hang this leg in an unproved refrigerator until such time as the patient condition warranted amputation. Therefore, the entire lower extremity was placed in large rubber sheet with ten ice bags inside this sheet and the latter then bound firmly about the limb. The situation was explained to the private nurses who kept the ice bags filled and the limb thoroughly refrigerated continuously for 14 weeks.

Lung findings are present from time of admission and true pneumonia was diagnosed at the end of 45 hours. His temperature rose to 103 degrees Fahrenheit, respiration 32, and pulse 80. Sulfadiazole therapy was instituted and oxygen therapy continued for 2 weeks. At no time during this period could this patient have withstood the ordeal of an amputation if the same had been demanded by the presence of most gangrene threat.

However, because of the refrigeration the right lower extremity remained in very well preserved condition. The foot and ankle varied from slightly bluish to dusky appearance. The remainder of the leg varied in color from bluish to pinkish base. A line of demarcation developed at the junction of the lower and middle thirds of the thigh. As one approached this line from the knee the color varied from pinkish to slightly bluish but above the line of demarcation the refrigerated thigh looked perfectly normal. Still no pulsation could be felt in any of the vessels of this extremity. It is noteworthy that the extremity, deprived of all circulation at the junction of the middle and lower thirds of the thigh to the toe for period of 9 days, at no time had developed blebs, any evidence of moist gangrene, and no sign of secondary infection. The tips of the toes have showed evidence of dry leathery gangrene. On the 10th day amputation was decided upon.

On the day prior to amputation thermocouple readings were made in this refrigerated extremity in order to ascertain the temperature deep in the tissues. Similar readings were made after the tourniquet had been applied and just before amputation. These showed temperatures 1 to 2 inches below the skin varied from 32.7 degrees to 34.4 degrees Fahrenheit before the tourniquet was applied, and temperatures varying from 25 degrees to 33.5 degrees Fahrenheit after the application of the tourniquet.

At 8 a.m. March 6, soft rubber tube was wrapped twice about the patient's thigh near the junction of the upper and middle thirds. It was placed sufficiently tight to close off all arterial and venous flow. A rubber sheet was tied about the thigh some 3 inches above this tourniquet and was then wrapped about the remainder of the lower extremity as a trough. Four buckets of cracked ice were poured into the trough and the ice thoroughly packed around the limb and foot extending well above the tourniquet. The head of the bed was elevated in order that while hot water could escape from this trough. Checked as was necessary as was necessary to keep the extremity covered. Three hours later the patient was taken to the operating room and the junior author proceeded to amputate just above the junction of the middle and lower third without any other anesthetic whatsoever being used except three drinks of whiskey. Throughout the procedure the blood pressure never varied. There was absolutely no shock from the operation. The arteries of the thigh at the site of amputation were healthy red color. After the tourniquet was removed the vessels met and bled freely. The stump was closed tightly without drainage after installation of sulfadiazole crystals. Patient was returned to his room in excellent condition and ate good lunch.

Following the operation patient continued to run low-grade fever which had persisted following his pneumonia. On March 9 he began to expectorate quantity of foul smelling purulent material. X-ray of the chest was taken and revealed fluid level in the midportion of the right lung which appeared to be behind the hilum. Upon returning from the x-ray laboratory the patient developed violent attack of coughing, became cyanotic and dyspneic, and suddenly brought up large amount of pus. It seemed that he was drowning in this pus until the resident performed hurried tracheotomy and large quantities of the material were then aspirated through the tracheostomy tube.

On March 9 Dr. Willard Van Haelst performed resection for the purpose of evacuating an empysemal abscess. On April 8 patient developed still another abscess in the right groin at the site of an old hematoma. It was drained and healed a few days thereafter. The tracheostomy

wound was allowed to close on April 23. In spite of the presence in this patient of so much infection developing so shortly after the amputation, his stump healed by primary intention with the exception of a small area 2 by 3 centimeters which sloughed. After debridement this small area healed readily. Patient was discharged from the hospital on June 5 having completely recovered from all of his wounds and their complications.

REFRIGERATION AND ANESTHESIA

Refrigeration is the chilling of tissues. Freezing damages tissues as in frost bite; refrigeration does not. The tissues of an extremity may be refrigerated, that is, chilled, to within a few degrees of 0 centigrade for many days and still retain their viability. For example, the upper thigh, in Case 2, was refrigerated for 10 days with the temperature lowered to approximately 34.3 degrees Fahrenheit and yet it remained viable and showed no deleterious effects after the lower thigh was amputated. Even that portion of the thigh which was below the tourniquet approximately 3 inches and which was refrigerated for 3 hours after the tourniquet was applied, showed no damaging effects from this ordeal after the tourniquet and refrigeration were removed. In several other cases of amputation under ice anesthesia, that portion of the stump below the tourniquet varying from 3 to 6 inches, has remained viable and showed good healing power after removal of the tourniquet and refrigeration.

In a recent article Mock and Mock, Jr describe fully the technique of refrigeration anesthesia. They give chief credit for developing refrigeration as a method of preservation of tissues and as a form of anesthesia to Dr. Frederick Allen of New York, and his co-workers, Drs. Crossman, Ruggiero, Hurley, and others who pioneered in this field. In our opinion the 2 cases cited re-emphasize the value of their contribution.

CONCLUSIONS

1. Two cases of gangrene of the lower extremity complicating fractures of the pelvis are herein reported. High amputations were performed in both of these cases with recovery.

2. Injuries to the iliac and femoral vessels in the presence of fractured pelvis present exceedingly serious problems to the surgeon. These complications are not sufficiently stressed in our

textbooks on fractures or in the surgical literature. A search of this literature covering some 3,108 cases revealed only 13 cases in which injuries to the external iliac or femoral vessels were mentioned. In only 3 cases was gangrene of the lower extremity listed. Only 2 of these patients were subjected to amputation with one of these recovering. The other, a gangrenous case, not amputated died.

3. It is evident from reading the various case reports that emergency amputations as well as other emergency operations done during the early hours of shock and hemorrhage following fractured pelvis are exceedingly dangerous and have added greatly to the mortality rate. The authors believe that, in the case of amputations, refrigeration of the gangrenous extremity will hold infection and spreading moist gangrene in abeyance, thus giving a period of days or weeks in which to get the patient in condition to withstand the ordeal of amputation. Eventually, the amputation can be performed under refrigeration anesthesia without shock and without possible general anesthetic complications. In our experience even spinal anesthesia is not altogether devoid of shock.

4. By the refrigerating of the extremity, thereby holding the gangrenous process in abeyance in the more distal portions, time is gained for the development of a certain amount of collateral circulation. Thus amputations which otherwise might seem necessary high in the thigh may eventually be limited to more distal portions.

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COMMUNUTED FRACTURES OF THE DISTAL END OF THE RADIUS

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THE need of change in the methods of treating comminuted fractures of the distal end of the radius is evident from a evaluation of the average end-results, expressed by the patients in the all too frequent complaints: "My hand is weak and stiff and sore and besides my wrist is deformed." Roentgenographic studies a year after the accident will, in a high percentage of cases, reveal shortened radius, maltilted articular face, depressed or irregular joint surface and a relative enlargement of the ulnar styloid.

Our clinical studies, fortuately have demonstrated that these undesirable sequelae can be minimized by the use of protracted traction. Success calls for a prolonging of traction until consolidation is complete. While reduction with restoration of radial length is usually not too difficult to obtain, it is difficult to maintain because the intact ulnar shaft acts as a pivot point for the contracting strong radial muscles.

The original shortening in many of these wrist fractures is due not altogether to overriding or telescoping of the many fragments but to an actual crushing of the cancellous bone. In these cases an apparent end-to-end reduction will not suffice because the articular fragment must be pulled out to its normal relationship with the ulna. Furthermore it must be held in the extended position over a long period of time (3 to 4 weeks) and thus not only the filling in but the

aging of the cancellous bone to a degree sufficient to withstand the compressing force of the muscles.

Donald Murray and other pioneers in the adhesive traction method—Boehler, Murray, Meek, Mason, Harry Blair and other advocates of skeletal traction—have demonstrated the effectiveness of extension therapy. Early release of traction and immobilization, however, were advised by many surgeons through fear of finger, wrist, and elbow joint stiffness. Thus their procedures did not routinely reap the full benefits of traction because the extension and fixation were removed before consolidation was complete.

All the anatomic and functional benefits of a satisfactory reduction sustained through traction until immobilization is complete without fear of joint stiffness, are now possible with new technique. The basic principles of this procedure are reduction obtained through skeletal traction in conjunction with skeletal half-pin countertraction, and immobilization by use of a skeletal rock instead of cast.

TECHNIQUE

In traction a medium 0.060 K. Schmeer wire is passed perpendicular through the distal one-third of the shaft of the 2d metacarpal at an angle. Or it may be passed through the center of the 2d metacarpal. The wire is connected to a muscular holder or lock. For countertraction the half-pins of large 0.080 wire are inserted into

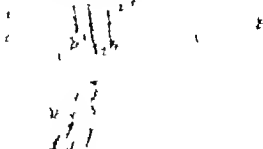


Fig. a. Max M. extension comminuted the distal end of the radius. b. Excellent aligned elsewhere, with plaster cast for im-

se patient in great deformity the

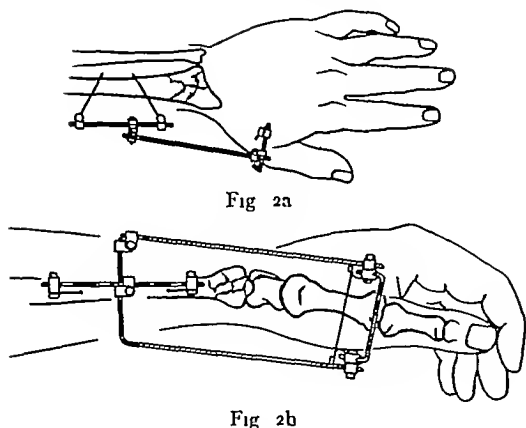


Fig 2a

Fig 2b

Fig 2 a, Illustrating the location of transfixions and means of obtaining castless immobilization. Dorsal tilting of the articular face can be controlled by immobilizing the traction force so that the 2d metacarpal remains in a straight line with the radius. The traction wire can be placed either through the 1st metacarpal, as illustrated, or through the 2d metacarpal, as illustrated in Figure 8 b. The radial half pin fracture unit is joined to the metacarpal "U" by two small fixation rods, one straight and the other bent. This placement gives complete exposure for both lateral and anteroposterior roentgenograms. The complete unit weighs less than 3 ounces. c, The "U's" are made by bending a $\frac{1}{8}$ inch stainless steel pin. The sides of the "U" should not be warped or scratched during the bending process. A small double clamp is slipped onto each side of the "U" before the wire is fastened into the pin clamps.

Fig 3 Cross section of left forearm at a level about 3 inches above the wrist joint with transverse axis of elbow perpendicular to the floor and hand in full supination with palm perpendicular to the floor.

Fig 4 Cross section through the midportion of the shaft of the metacarpal of the thumb.

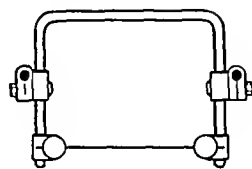


Fig 2c

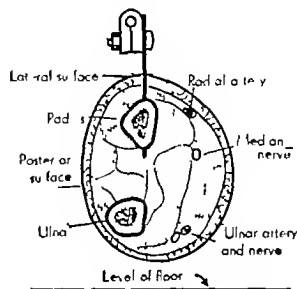


Fig 3

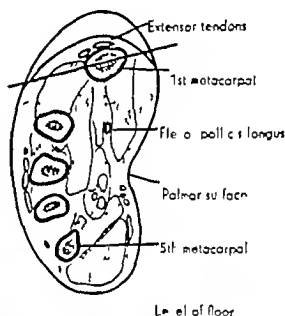


Fig 4

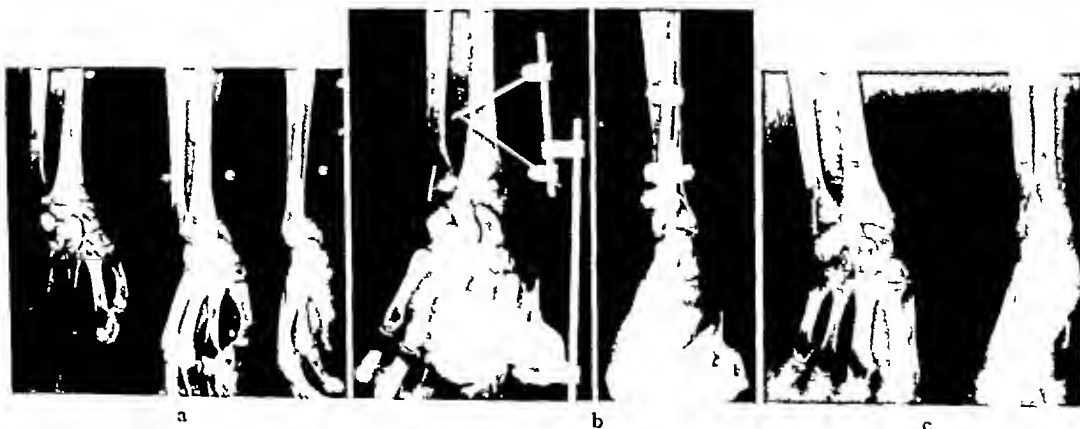


Fig 5 a, Mrs. A. D., November 30, 1942. b, Roentgenogram on December 7, 1942, 1 week after reduction. The fracture of the ulna was held with a small band because with her age of 50 it was thought advisable to maintain

complete function not only of the fingers but also in rotation of the forearm. c, Roentgenogram, February 23, 1943, nearly 3 months after the accident. Note that the length of the radius was maintained in spite of immediate function.



Fig. 6a.



Fig. 6b.



Fig. 6c.



Fig. 6d.

Fig. 6. a, M. U. F. anteroposterior type of comminuted fracture with superiorly displaced central articular fragment. b, While the transfixions and fixation rods maintain radial length and apposition, the small central articular fragment is still unreduced. c, This articular fragment is replaced through dorsal incision, without disturbing the fixation rods, and the crater cavity in the bone was filled with small bone chips taken from the adjacent shaft. Roentgenogram is taken on the operating table. d, Roentgenogram 7 months later.



Fig. 7. Application of apparatus in 3 different cases. The patient is the center. As unfortunate enough to have fractures of both radius and ulna at the wrist joints. With bilateral fractures such as this, the patient could be very seriously disabled if both hands were immobilized in plaster. The fracture of the left radius was not comminuted, yet 1 1/2 months after fracture in the right hand the end of 3 months she had better function in the right than in the left hand.

angle into the lateral aspect of the radius just above the fracture site and are joined together into a half-pin fracture unit.

Manual reduction, under adequate anesthesia, is accomplished by an assistant applying countertraction to the flexed elbow as the operator pulls on the second finger or on the thumb, whichever was transfixed and manipulates the fracture with the other hand. Two fixation rods hold the reduction. The fluoroscope serves to check on general alignment but roentgenograms should be taken for final check. Sufficient traction must be exerted to restore the radius to normal length. If in doubt as to the proper amount of elongation and of the tilt of the articular surface, a roentgenogram of the opposite wrist should be taken.

Immediate active function must be initiated upon. As the patient is coming out of the anesthetic, he should be instructed to start moving his



Fig 8 a, Cross-section through the midportion of the shaft of the 2d metacarpal and through the superior end of the proximal phalanx of the thumb. In transfixing the 2d metacarpal, its head is pressed dorsally while the heads of the 3d and 1st metacarpals are pressed volarly. The wire may be bent as it is fastened into the "U" so that the ends of the "U", when attached, will not press into the dorsum of the hand. b, Mrs M V, February 14, 1944, demonstrates the placement of the traction wire through the 2d metacarpal. c, Mrs R C, February 16, 1944, another case showing placement of the wire through the 2d metacarpal.

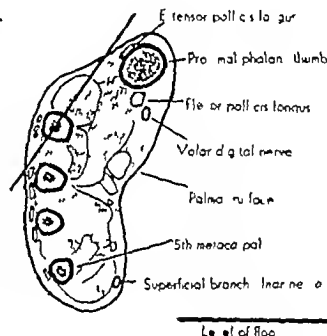


Fig 8a.

fingers, later on grasping doorknobs, combing his hair, typing and writing, opening doors, using fork and spoon, and shaking hands. A sling should not be used unless there is a great deal of swelling, and then only for a few days. By not pampering or treating the patient as a cripple, the aggregate suffering will be held to a minimum. Immediate use of fingers and arm is the keynote to near perfect functional restoration.

In associated ulnar styloid fracture may be treated in one of the following manners: (1) ignore, since with even the firmest of plaster fixation many fractures do not unite but go on to a fibrous union and satisfactory function; (2) apply a very thin but snug plaster cast over the fixation rods, molding the plaster so as to approximate the ulnar fragments; (3) directly affix the styloid fragment by means of a metal bridge through a skin puncture incision or by placing a very slender screw through a 1 inch skin incision; (4) resect and discard the distal fragment subperiosteally if early

rotation of the forearm is imperative (a helpful step in preventing deformity from displacement or excess callus).

Compound fractures are routinely treated with transfixions inserted either before or after débridement; if Orr's method is elected, the plaster is preferably applied over the fracture units and fixation rods after they have been covered with sheetwadding.

Optional technique. If soft tissue injury or other fractures of the radius prohibit inserting transfixions in the radius, then a snug cast extending to the upper arm with the elbow at right angles may be used for countertraction. With such fixation roentgenograms should be taken at frequent intervals as shortening is prone to occur. If shortening does occur, the traction should be increased by forcing the metacarpal "U" further distally on the fixation rod. The fixation rods should both be of the bent type. Their superior ends are firmly fastened to the cast by means of



Fig. 9a.



Fig. 9b.



Fig. 9c.



Fig. 9e.



Fig. 9g.



Fig. 9h.



Fig. 9j.



Fig 9a.

Fig 9b

Fig 9 Mrs E B, age 63 a, Roentgenograms of malunion of right radius into the wrist, taken on October 11, 1943, when patient first consulted us, 2 months after the accident b, On October 14, 1943, the lower end of the ulna was subperiosteally resected, after which a rotation osteotomy was performed through the old fracture line in the radius Small grafts were removed from the adjacent radial fragments and the resected portion of the ulna was cut up into many small pieces and placed between the radial fragments These x ray pictures were taken immediately following operation c, Final roentgenograms taken on February 17, 1944

Fig 10 a, Mr C S, October 13, 1943, comminuted fracture of distal end of radius with marked deformity and posterior displacement b, X ray pictures taken after reduction the same day c, Photograph of patient the day after reduction d, Final roentgenogram taken December 7, 1943 Note that while there is complete length of the radial styloid there is slight shortening of the radius on the ulnar side, which may be accounted for by the fact that transfixions were removed at too early a date

Fig 11 Mrs P N, age 54 a, Roentgenogram showing very extensive comminuted fracture of an osteoporotic radius So much comminution and loss of bone salts were noted that it was our opinion that union would be delayed for a long time or else achieved by a sacrifice in length of the radius, so 3 days after the accident we transplanted small grafts from the anterior crest of the ilium Then the fracture was treated in the routine manner with two half pins in the radius above and one medium size Kirschner wire through the 1st metacarpal b, Roentgenograms on



Fig 10c

September 3, 1943, immediately after reduction c, Final roentgenogram on November 29, 1943 (The 3d finger amputation was the result of a previous accident and not a sequelae to transfixation)

a plaster bandage, and the fixation rods meanwhile are kept parallel to each other and at about right angles to the "U" so as to facilitate later adjustments

Arthrodesis of the wrist The transfixions can be used for a contact technique and fixation rods should then be reinforced with a light, short cast

Malunions of wrist fractures can be successfully managed with this technique Posterior tilting of the articular face and angulation can be corrected by means of a curved osteotomy, through a lateral incision The enlarged and prominent end of the distal ulna is corrected by a subperiosteal resec-

tion of a sufficient amount of the lower end of the ulna and the styloid process, whether it is united or ununited The resected bone can be cut up into small pieces and inserted between the radial fragments to fill in any space that remains after the fragments have been realigned Again, immediate and very persistent active and passive movements of the fingers will restore function during the period of callus formation and consolidation

Period of immobilization should be much longer than the generally accepted time of about a month Removal of traction at this time permits the muscular pull to compress the still "green"

callus with resulting radial shortening, tilting and deformity. Traction for 2 or 3 months, as indicated in roentgenograms, is a safer period of immobilization in extensively comminuted fractures, provided the fingers and hand are actively used every hour of every day during this period.

Some will question this prolonged period of traction. With this technique, however there is no immobilization of the metacarpophalangeal or interphalangeal joints of the thumb and fingers. Function including rotation of the forearm is

surprisingly good during this period, and a short while after the tractions are removed there is already a satisfactory range of motion at the wrist joint.

XX VMD.

The cause of the all too frequent deformities and sequelae following comminuted fractures of the distal end of the radius is discussed. A method providing castless fixation with immediate and full function of the fingers is given in detail.

EDITORIALS

SURGERY Gynecology and Obstetrics

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1905-1935

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APRIL, 1944

TECHNIQUE OF VENIPUNCTURE

IN the pursuit of knowledge and achievement in various major fields of medical practice, we often neglect to learn ourselves and to teach our students the less glamorous and more practical aspects of technical therapeutics. There is no field in which this is truer than in the field of intravenous therapy and venipuncture.

Venipuncture is in general poorly performed, particularly by many students and internes. Although this can be largely corrected by systematized instruction, there have been in past years few institutions in which it has seemed of sufficient importance to warrant special attention. This may be explained by the fact that intravenous therapy in all forms has never been used as intensively as it is today. The technique of venipuncture is not generally taught to medical students or internes, therefore, it is not uncommon to see the arm of some ill patient a mass of punctures and hematomas from the

unskilled attempts to get a needle into a vein. Worse than this, it is not uncommon to see multiple scars on the various extremities which are the result of having to cut down on veins. Although this was common practice in the past, I have seldom seen one who is adept at venipuncture have to resort to this procedure, even in the case of an infant. The need for instruction in venipuncture is obvious if one stops to consider the part venoclisis plays in modern medical practice. In any large general hospital the daily number of venipunctures will run into the hundreds. These might be for the administration of fluids, whole blood, plasma or other blood substitutes for the introduction of medicaments such as the sulfonamides, penicillin, or arsenical drugs, for obtaining blood for morphologic or chemical study, for the injection of dyes for diagnosis, for the introduction of sedatives such as the barbiturates, to obtain blood from donors for refrigeration or plasma, and for the administration of anesthetics. Added to this is the outstanding importance of intravenous therapy in our armed forces, for the administration of plasma, whole blood or anesthetics, where conditions are often adverse and delay may be fatal.

In the majority of cases venipuncture may be accomplished without difficulty regardless of whether the technique is good or bad. It is liable to prove difficult, however, in cases in which veins apparently are not accessible, in cases of edema or shock, and in cases in which the patients are infants. There are many methods of performing venipuncture, and various types of equipment are used for this purpose. No one set of rules or no single type of equipment can be labeled as the right one

Any method which produces consistently good results in all cases is satisfactory. However to accomplish venipuncture in the cases which have just been mentioned and make it appear easy it is necessary to practice a standard technique which is used in all cases whether the procedure is difficult or easy. If the need for intravenous therapy is urgent as it is likely to be in military surgery standard rules for equipment and methods must often of necessity be forgotten. Under such circumstances, the use of an antiseptic or local anesthetic may be outweighed by the urgency of instituting prompt therapy. However minor technicalities which facilitate rapid venipuncture are even more important on the battle field than they are in civilian practice.

The first step toward the institution of efficient venipuncture is the standardization of equipment and the training of internes and residents in the use of this equipment rather than permitting each man to use for example various unusual types of needles and other equipment. Standardized intravenous sets relieve the surgical supply room from maintaining a lot of unnecessary sterile equipment. Speaking in terms of economy for the institution this standardization saves time and money and increases efficiency.

Instruction in methods to facilitate venipuncture may be as diversified as the instructor's ideas and experience. Among other things, it should include the use of a local anesthetic by infiltration prior to venipuncture. In this age when the relief of pain has become highly developed one is not justified in hurting a patient even for the insertion of an intravenous needle if its caliber is 18 gauge or more. If a patient's veins appear to be unsatisfactory in one part of an extremity each part of the four extremities should be examined in order to locate the most suitable veins before an attempt is made to insert a

needle. Students should be instructed in the situation of all the veins accessible for intravenous therapy and anesthesia since many persons seem to feel that intravenous injection is confined to the veins in the antecubital fossa. One frequently sees an interne struggling to insert a needle into a small vein in one arm when the other arm contains veins that are entirely satisfactory for this purpose. Another common failing is to attempt venipuncture before the veins have been filled to the normal degree. One a time is well spent beforehand in using every possible method to distend the veins as much as possible instead of wasting it by making multiple punctures on a vein that is partially collapsed. These methods include among other things, careful adjustment of the tourniquet, massage, syringing and other passive manipulations and if necessary moist heat applied for half an hour before venipuncture is tried. A little time spent on these preliminary measures will reveal veins where none previously could be seen.

There are many types of intravenous needles. The chief points are that the needle should be sharp and that its caliber should be adequate to permit the flow of all types of fluids. Except in cases in which the patient are infants and cases in which venipuncture is exceptionally difficult the needle should be at least 18 gauge. In surgical cases and in those in which rapid infusion is required, a 15 gauge needle is preferred. Even cold blood will run freely through a 15 gauge needle. This is of great importance in the treatment of shock and acute loss of blood on the operating table. The relation of the bevel of the needle to the size of the vein is important. Whereas it matters little whether the needle is inserted with the bevel up or down in cases in which the veins are large if the veins are relatively small inserting the needle with the bevel down facilitates venipuncture.

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

THE small handbook *Physiology of Aviation* by Gemmill contains the material covered in the lectures on physiology given in the School of Aviation Medicine, Naval Air Station, Pensacola, Florida. The changes in physiological functioning of the human organism exposed to decreased barometric pressures are described with exceptional clarity. This also presents the statement of the gas laws and their application to aviation medicine. In describing the comparative volumes of gas in the intestinal tract at sea level and at various altitudes, the author inadvertently employs the table of relative gas expansion applicable to dry rather than moist gas. Thus, an ascent to 38,350 feet will result in an volume of gas saturated with water vapor occupying space almost seven times that at sea level, instead of five. The physiology of respiration and circulation as affected by high altitude could hardly be presented in more concise and illuminating fashion. The book can be highly recommended not only as a text for students but also those who have the responsibility of teaching medicine in medical schools.

A. L. BARNES

A SHORT and excellent presentation of relatively new specialty aviation medicine is made in *Aviation Medicine*. The author points out that the flight surgeon must be trained in physiology, internal medicine, ophthalmology, otology, otolaryngology and psychology insofar as these specialties are concerned with flying. The physical examination of the aviator is described, with special emphasis on those defects which might handicap pilots. The pilot is not only given thorough general physical examination but special tests are conducted on the eyes, ears, nose and throat, and equilibrium. In addition, he must pass careful neurological and psychiatric examination. The monograph includes brief but clear description of the strains and stresses of flight, such as the effects of high altitude, aero-embolism, high speed, cold and wind. In the light of recent investigation, some of the conclusions concerning the physiology of high altitude may have to be modified. Thus, it has been shown that individuals may tolerate partial pressure of oxygen of 4 millimeters of mercury in the alveoli all for considerable period of time. The book may be highly recommended. The author is an authority on medical examination in flying personnel.

A. L. BARNES

THE handbook of urology by Lowsley and Lewin¹ has been brought up to date. The opening chapter explains the new blood plasma coagulants and illustrates their use as well as giving a brief résumé of dosages and clinical indications.

Usual urological procedures, such as preparation for cystoscopic and pyelographic examinations, catheterization of patients, are given in detail. Likewise the common laboratory procedures and urology are fully outlined. The names and uses of the special instruments and materials are presented and their care and maintenance emphasized. Special emphasis has been placed on sulfonamide therapy and the necessity of adequate fluid intake and periodic blood examination upon patients receiving sulfa drugs. Much of the book is devoted to the surgical aspect of urology in attempt to familiarize the nurse with operations and factors influencing good results. The dietary management of renal diseases is included together with sample diets.

The careful perusal of this text by nurses caring for urological patients will relieve the heavy burden of the time consuming duty of explaining various procedures and orders. Also the book is a ready reference for the urologist himself. So at times it can explain technical procedures in terms the average layman can understand. This book should be in the library of all nursing and medical institutions.

JURIN L. FORD

IT is also of interest to compare textbooks of surgery issued during a period of war with that which appeared during previous wars. While the volume *Textbook of Surgical Treatment* by Lister, Smith and his collaborators is in no way a manual, it does serve to illustrate basic surgical principles practiced at the present time. When compared with similar works published during World War I it can be an excellent medium of distinction between the types of surgery practiced now and those done a generation ago. It does not offer to give evidence that the improvement in mortality and morbidity rates that are now becoming so apparent among casualties, as well as in civilian surgery is not due simply to the use of blood plasma, sulfonamides and penicillin as many would have us believe but is primarily the result of better trained surgeons who possess better knowledge of the fundamental principles that form the basis of good surgical care.

JURIN L. FORD

¹Reviewed by: (1) Chalmers I. Thomas, M.D., Springfield, Ill., and (2) Lawrence M. D. Thomas, M.D., University of Michigan, Ann Arbor, Mich. Edited by Henry Christian, University of Illinois, Urbana, Ill. New York, London, Toronto: Oxford University Press, 1943.

¹Reviewed by: (1) Chalmers I. Thomas, M.D., Springfield, Ill., and (2) Lawrence M. D. Thomas, M.D., University of Michigan, Ann Arbor, Mich. Edited by Henry Christian, University of Illinois, Urbana, Ill. New York, London, Toronto: Oxford University Press, 1943.

The authors chiefly represent the schools of Glasgow, Edinburgh, and Aberdeen, and the volume reflects the sanity and progressiveness that one has long since learned to expect from these institutions. In slightly over 500 pages an effort has been made by the author and his contributors to cover the entire field of surgery including not only the ordinary surgical techniques but their indications as based on underlying physiologic principles as well. Most subjects have thus been treated briefly and while for the most part this has been done clearly it lends a certain rigidity to the consideration. As an example may be offered the relatively lengthy treatment of the two-stage operation for carcinoma of the rectum with bare mention of the one stage abdominoperineal procedure of Miles.

Greater attention has wisely been given to those surgical operations that are more commonly used. The student is thus not confused by obsolete techniques or numerous modifications of a simple technique. This reviewer would prefer to have seen more space devoted to the chemistry of electrolyte balance and to nitrogen metabolism. The pre-operative preparation for surgery of gastric and large bowel carcinoma could likewise be extended. The preference for sulfapyridine over other sulfonamides in surgical practice may also be questioned as well as the preference of the rectal route for the parenteral administration of physiologic salt solution. But such criticisms as these are minor and probably represent an individual opinion. They do not detract materially from the general excellence of the book. This volume will be found invaluable to the young surgeon and of considerable use to the expert.

NATHAN WOMICK

THE routine use of the slit lamp in examination of the eye is now recognized as necessary. *Bio-microscopy of the Eye*¹ by Berliner makes available an atlas of over 500 illustrations including 40 pages of vivid color plates. There is a comprehensive discussion of the changes which may be found in the lid margins, conjunctiva, cornea, and anterior chamber with the slit lamp. A second volume due in 1945 will include iris, lens, and vitreous. The seven hundred pages are printed on good paper in print large enough to read easily and comprise an up to date interesting account of many of the unusual as well as the usual conditions of the eye. Bibliography and index are appended. The development of the slit lamp including the various instruments and technique of its use are described. The chapter by Sugar on the gonioscope and anterior chamber angle is a valuable addition.

The superb *Atlas* by Vogt (2 volumes, 1930) because of the German text and high price has not been as widely used as this new volume by Berliner should be. The Von der Hedyt English translation of the 1921 Vogt *Atlas* came at an earlier day when the slit

lamp was not as widely used as now. There are also less extensive books by Butler (1927), Meesman (1927 German), and Koby (1930). Berliner may be recommended as the best large text which is easily available on the subject.

GAIL R. SORFER

THE author of *Clinical Diagnosis by Laboratory Examinations* has accomplished an enormous task and has produced a far more comprehensive and complete work on the subject than has been published up to this time. Dr. Kolmer has divided the text into three parts: I. The Clinical Interpretation of Laboratory Examinations, II. The Practical Applications of Laboratory Examinations in Clinical Diagnosis, and III. Technique of Laboratory Examinations. In part I, the subject is discussed from the viewpoint of the examination concerned somewhat more than one half the book being devoted to this subject. Part II is concerned with the laboratory findings observed in diseases which are grouped in systems. Part III consists of a somewhat limited, but still adequate presentation of laboratory technique which occupies about 130 pages.

The work is well conceived and executed and really stands alone in its field at the present time. In view of its size, it is not surprising that there have crept into the text some statements that appear to be erroneous. Thus on page 11, the life of the transfused red cell is said to be 12 to 13 days, while on page 486 it is placed at 3 to 4 months. On page 120 the paragraph about the van den Bergh reaction seems confused. The use of prothrombin determinations in liver function tests is omitted. The author follows general custom in urging the addition of para-aminobenzoic acid to culture media though there is some evidence that the necessity for this addition has been overemphasized. There is a good deal of confusion in respect to compatibility tests in reference to the Rh factor. The author's statement is that the Rh agglutinin "agglutinates corpuscles only at low temperatures," although Levine recommends that such compatibilities be carried out at 37 degrees C. As a matter of fact, it should be recognized that a compatibility test is not a reliable protection against transfusion reactions due to the Rh factor. On page 611 it is stated that the "A Z" test may be positive 5 to 14 days after the first missed menstrual period, while on page 614 the time is given as 5 to 14 days after conception. The author does not discuss the use of cover slips in making blood films. He recommends the use of potassium oxalate as anticoagulant in hematocrit determinations when it seems to be generally agreed that Heller and Paul's mixture of potassium and ammonium oxalate is superior for this purpose. In common with most authorities, the author gives the sedimentation rate normally from 0 to 8 or 10 millimeters per hour. There is grave doubt whether a proper rate in normal blood can be zero. Such a result is so frequently the effect of im-

¹BIO-MICROSCOPY OF THE EYE. SLIT LAMP MICROSCOPY OF THE LIVING EYE. By B. L. Berliner M.D. Vol. 1. New York and London: Paul H. Hoeber Inc. 1943.

²CLINICAL DIAGNOSIS BY LABORATORY EXAMINATIONS. By John A. Kolmer M.S., M.D., Dr. P.H. Sc.D., LL.D., F.A.C.P. New York and London: D. Appleton Century Co. 1943.

proper collection of the sample that a doubt should always be raised when this result is obtained.

However these admittedly minor criticisms and should not be regarded as in any way detracting from the value of the work as a whole. The discussion of the interpretation of bacteriological examinations should be read by every physician and the comments on the leucocyte count in appendicitis also deserve special mention. The book can be recommended unreservedly to physicians in every branch of medicine.

It is a large book of 330 pages whose size could have been reduced somewhat by judicious use of small type and the omission of textual repetition of some of the many excellent tables.

RALPH G. STRAIN.

THE book *Peripheral Vascular Diseases (A glossary)* by Saul S. Samuels, is one of the Oxford Medical Outline Series designed to use the author's own words, with the purpose that it will stimulate either interest in every phase of peripheral vascular diseases among students and graduate physicians. This little book is based essentially on the second edition of the book *The Diagnosis and Treatment of Diseases of the Peripheral Arteries* published in 1910. There is added an excellent outline of the anatomy of the blood vessels and of the autonomic nervous system of the extremities as well as an outline on varicose veins, thrombophlebitis, and diseases of the lymphatics of the extremities. Each chapter is followed by well selected bibliography.

The outline on thromboangiitis obliterans and arteriosclerosis obliterans are quite complete with respect to etiology, diagnosis, and treatment. The author takes categorically that lumbar sympathectomy is not indicated in thromboangiitis obliterans. While he recognizes that sympathectomy is of little in arteriosclerosis obliterans because of the absence of vasospasm the great majority of cases, he does not have his objection to this procedure in Buerger's disease on this premise but merely states that sympathectomy does not forestall any of the complications of this disease. In this opinion, he is at variance with many workers in this field who advise sympathectomy in those cases of Buerger's disease in which vasospasm can be demonstrated by spinal anesthesia and nerve block. It should be said, however, that Dr. Samuels has had very wide experience in this field. His opinion therefore should be very seriously considered.

The reviewer should have desired to see more adequate outline on varicose veins and thrombophlebitis. While these conditions are not nearly as serious in their implications as are Buerger's disease and arteriosclerosis obliterans, the confusion concerning their proper classification and treatment is almost as great. A more detailed outline of the disturbed hemodynamics in varicose veins and of the

treatment of both this condition and of thrombophlebitis in the light of the author's extensive experience would have greatly enhanced the value of this portion of the book.

On the whole, the book attains the purpose of the author admirably. It can be heartily recommended as a synopsis of the subject of peripheral vascular diseases.

J. T. CURTIS

THE author of the excellent work *Practical Anesthesia* succeeded in condensing an unusually large amount of essential and valuable information into a readily serviceable outline form. Every other page is blank, thus affording the reader ample space in which to incorporate references, sketches, and pertinent notes.

Although the author has purposely omitted discussion of controversial points, the reviewer believes that many rectal surgeons will take issue with the statement that either as an anesthetic agent provides complete muscular relaxation. With respect to the anal sphincter mechanism complete relaxation can be obtained with ether only when the deep stage of anesthesia is reached, with concomitant encroachment on the margin of safety. In the reviewer's opinion anal sphincter relaxation can be established more easily and with greater safety by means of regional block anesthesia, i.e. spinal or sacral.

The author lists both the advantages and the disadvantages of ether but for caudal and for spinal anesthesia he states only their disadvantages. He is right in saying that caudal anesthesia fails in 30 per cent of cases, but he fails to add that sacral anesthesia which can be established during the "waking period" of the caudal portion of this procedure reduces the failure almost to zero, provided the anesthetic agent is properly placed.

The reviewer is particularly pleased to find a practical presentation of the problems of congenital malformations. When the surgeon is suddenly confronted with the urgent need for this information, he wants it quickly—and here it is.

The presentation of the major surgical subjects is excellent indeed, especially in view of the limitation of outline form. For this work the author recommends either general or spinal anesthesia. In view of the importance of colonic and major rectal surgery and because of the great advantage of teamwork of anesthesiologist and surgeon the reviewer believes that it would have been well to mention the invaluable contribution of continuous spinal anesthesia supplemented as necessary by the intravenous administration of sodium pentothal.

With regard to the surgical treatment of piles, the author's method of complete excision followed by packing the open wound is satisfactory for the most part, in civilian practice. In military surgery however this method results in far too much

ick days Until we learn how to accomplish successful primary closure, the reviewer feels that "compromise" procedures are worth trying One such method is the "exteriorization" operation as described by Buie

Students and general practitioners should find this book a valuable guide and a stimulus to further study

J PEERMAN NESSELROD

THE same pattern which has been so successfully used in previous years is followed in *The 1943 Year Book of Radiology*¹ This text again serves as a handy and rapid reference source for one interested in radiology

The usual high standard for the reproduction of films has been maintained And in spite of the war there is practically no diminution in the size of this book

R G WILLY

THE reviewer read *The Education of Nurses*² by Isabel Matland Stewart with great benefit and interest A more descriptive title would be "The Education of Educators of Nurses" for the "book is designed primarily for professional students and workers in the field of nursing education" It is the latest in a series of Macmillan nursing education monographs and intended as a general introduction to the other volumes of the series which take up specifically and in more detail the various activities and problems involved in nursing education A very commendable special purpose of the book is "to provide a general orientation for non-nursing groups who are becoming increasingly interested in this branch of education and aware of their responsibilities in relation to it Such groups include board members and administrative officers in hospitals, nursing service agencies, higher educational institutions, members of state and other accrediting bodies, interested individuals in the allied professions of medicine, public health, and education, parents and friends of student and graduate nurses, responsible

¹THE 1943 YEAR BOOK OF RADIOLOGY DIAGNOSIS edited by Charles A. Waters, M.D., and Whitmer B. Fifer, M.D. THERAPEUTICS edited by Ira I. Kaplan, B.Sc., M.D. Chicago: The Year Book Publishers Inc.

²THE EDUCATION OF NURSES: HISTORICAL FOUNDATIONS AND MODERN TRENDS By Isabel Matland Stewart R.N. A.M. New York: The Macmillan Company 1943

government officials and public-spirited citizens"

The historical foundations and trends and the reasons therefor are discussed in a general way in eight chapters Each chapter is devoted to a special period of years, arbitrary in size because of their particular significance in the development of nursing education The presentation is clear and concise, well documented, and at the end of each chapter are appended a number of appropriate provocative questions

GEORGE H. COLEMAN

DESIGNED as a laboratory guide for under graduate students in a course in experimental surgery, the purpose of McCaughan's *Experimental Surgery*³ is not to teach surgical technique but to emphasize fundamental surgical principles by laboratory experimentation This method has been of incalculable value in the undergraduate teaching of physiology and pharmacology but has not been employed to any great extent in the teaching of surgery Complete instructions are provided for conducting a class in experimental surgery together with simple methods for performing operations under aseptic conditions and a series of thirteen exercises chosen to demonstrate various surgical problems At the close of each chapter there are a bibliography of important papers and a list of questions admirably designed to bring out the important features of the subjects under discussion

LESTER R. DRAESTADT

THE tables included in *White Blood Cell Differential Tables*⁴ by Waugh are very useful in deriving rapidly the figures necessary for the construction of the hemogram, a further development of technical hematology, in which the total count of each type of white blood cell is computed from the usual total white blood cell count and the formula of differential percentages Such a hemogram affords a more comprehensive visualization and understanding of the whole blood picture and should have a much wider usage by clinicians

GEORGE H. COLEMAN

³EXPERIMENTAL SURGERY: A LABORATORY GUIDE FOR UNDER GRADUATE STUDENTS. By J. M. McCaughan D.S. M.D., Ph.D. St. Louis: The C. V. Mosby Co., 1943

⁴WHITE BLOOD CELL DIFFERENTIAL TABLES By Theodore R. Waugh B.A., M.D. C.M. New York and London: D. Appleton Century Co., Inc. 1943

CORRESPONDENCE

CARCINOMA OF RECTUM—A CORRECTION

In the March, 1944 issue of SURGERY Gynecology and Obstetrics the article entitled "Carcinoma of the Rectum: Conclusions Based on 100 Years' Experience with Combined Abdomino-perineal

Resection by D. Frederick A. Colter and I.
Henry K. Ransom error appears in Table II.
The fourth item in the table under the heading
"Palliative colonostomy" should read "Local in-
operable—1 yet free" ss

BOOKS RECEIVED

Books received are acknowledged in this department, and each acknowledgment must be regarded as sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

Order The *Secret of the Vow*, Tiana, 10 East
By Abraham R. Hoffender M.S., M.D. F.A.C.S. Chicago
The Vow Book Publishers, Inc. 643

T. D. EASTWICK, V. TRAC, 31 REAR, N. By North Da son, D.Sc., and James Frederic Daniels, D.Sc., H.C. Ferraon, by T. Newton Harvey, Cambridge. The University Press, New York. The Macmillan Co. 1941. CLOTHBOUND. 200 PAGES. \$ 1.00. THE UNIVERSITY AND THE UNIVERSITY NATURAL CLOTHBOUND. By G. G. D. Eastwick, 31, M.D. (Camb.) New York and London. Harcourt, Brace, 1941.

INVENTALS OF DEER TONGS By Vernon Tolmie.
N D ed of Philadelphia, London, and Montreal J B
Lippincott Co. 044.

APPLIED DISTRICT T PLAYS TO T WORTH
 NON U. NO TAYLOR THE DEPT. BY FRANCES SEED.
 ed Baltimore The Williams & Wilkins Co. 049

SC. 122. By Kenneth Medinby B.A. (Christ) 17. D
Oxford War Manuals. Edited by The Rt. Hon Lord
Horder G.C.B. London Humphrey Milford (Oxford
University Press) 1922.

FIELD-VARY SCORES (VOZNO-POLYE YA KATRE
47) A 21. 41 FOR DOCTORS IN BASE HOSPITALS. Pub-
lished by the V. M. Shkolov State Medical Institute at
Toms, Moscow State Publishing House for Medical
Literature ("Medits") of

LITERATURE (Journals) By JENNINGS C. LITACOFFER,
B.Sc. M.D. F.A.C.S. and of St. Louis The C. &
Mosby Co. 1941

5 VOLUMES OF MEDICAL TOXICOLOGY AND PHARMACOLOGY FOR STUDENTS AND PRACTITIONERS OF MEDICINE. By FORTNEY RAYSON DAVISON, B.A., M.Sc. Ph.D. M.B. and Ed. St. Louis The C.V. Mosby Co. 444

Oral Pathology: A Histological, Roentgenologic, and Clinical Study of the Diseases of the Teeth, Gums, and Mouth. By Karl H. Thomas, D.M.D. 2d ed. Lippincott Co. 1944. 444 pp.

1. Ho-Bu zoography. (vols. 1-10). By the
very Cooking. Publication No. 6 of Historical Library
Sale of the Library. New York: Schuman, 1941.

THE HARVEY COTTAGE COLLECTION OF BOOKS IS
AN UNCLASSIFIED PUBLICATION NO. 1 OF HISTORICAL LIBRARY
140 MEDICAL LIBRARY, NEW YORK 17, NEW YORK

4. *Atlas of a Torus*. T. Torus, J. C. Bollen, Grant, M. C. M. B., Ch. B. F. R. C. S. (Ed. 1) W. Vertebrate and Vertebral Column, Thorax, Head and Neck. Baltimore: The Williams and Wilkins Co. 1943.
M. W. S. 500. By Frederick C. M. 1943.
M. D. F. A. C. S. 5th ed. Philadelphia and London W. B. Saunders Co. 1943.

EXPERIMENTAL; Clinical Application to Tax
 SURV. By Asst. Prof. Wm. M. D. F. C. P. and
 Philadelphia, Pa. & February 1944.

THE TREATMENT OF THE INJURED OF FACILE BONES & LIGAMENTS. By John R. Erich, M.S. D.D.S. M.D. and Louis T. Austin, D.D.S. F.I.C.D. in collaboration with Bureau of Medicine and Surgery U.S. Navy. Philadelphia and London: W. B. Saunders Co. 1911.

PHYSICAL FOUNDATIONS OF RADIOLOGY By Otto Glaser
Ph.D., Edith H. Quimby Sc.D. Lauriston S. Taylor
Ph.D., and J. L. Weatherwax, M.A. New York and Lon-
don Paul H. Rother Inc. 644

LA FARMACIA TERAPÉUTICA DEL MUERTO SÉPTICA. I
Dr. Raúl García Valenzuela. Santiago, Chile. Imprenta
Universitaria, 1932.

By William J. Carrington, A.B. M.D. F.A.C.S. Ft. Lauderdale and New York J.B. Lippincott Co. 1944.

FRACTURES AND JOINT INJURIES. By R. Watson, M.D.
B.Sc., M.Ch.Orth. F.R.C.S. Vol. 1 and 2. 1941.
The Williams and Wilkins Co. 1941.

MEDICAL PHYSICS Edited by Otto Glaser, M.D.
Chicago: The Year Book Publishers, Inc., 1944

OBSTETRIC CASES. By D. Macdonald. Christchurch.
New Zealand N. M. Perry, Ltd., 941

PHARMACOLOGY By Michael G. Minkes, M.D. A.B.
A.B. Ph.D., with Foreword by Charles C. Lick, A.B.
M.D. Oxford Medical Outline Series. London, New York,
and Toronto: Oxford University Press, 1944

SURGERY

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FECAL FISTULA

A L. LICHTMAN, M D, and JOHN R McDONALD, M D, Rochester, Minnesota

DESPITE progressive improvements in surgical technique, persistent fecal fistulas continue to be encountered at surgical clinics. Search of the literature failed to answer many of the questions that arose in observation of a group of cases encountered recently. In most studies, the fistulas were attributed to surgical faults, and there was little consideration of lesions in the intestinal wall. Because of this, one finds little discussion of the factors which tend to cause persistence of fecal fistulas despite repeated attempts at repair. It is only in the past 10 years that fecal fistulas related to granulomatous lesions of the intestinal wall have received adequate consideration.

This investigation was undertaken in an attempt to provide a sound basis for the study of the causes of persistence of fecal fistulas and the utilization of this knowledge in the application of the proper treatment for the cure of the fistula. We concerned ourselves with persistent fistulas originating in the small or large intestine (exclusive of the duodenum and upper part of the jejunum), which occurred as unforeseen complications of abdominal operations. From 1930 to 1941, inclusive, 590 cases of fecal fistula were encountered at the Mayo Clinic. In 58.2 per cent of these the

external opening was in the right lower quadrant of the abdomen.

HISTORICAL

Before the work of Fitz, ulcerative disease of the terminal portion of the ileum was recognized as a common cause of fecal fistula. In the rush of enthusiasm involved in the recognition of the importance of appendicitis, the rôle played by other inflammatory lesions of the ileocecal region in formation of fistula was neglected for about 46 years. There was a tendency toward considering all granulomas of the ileocecal region to be of appendiceal or tuberculous origin.

Aretaeus of Cappadocia (circa 30-39 A D) incised an abscess of the right lower quadrant, producing a vesical and external fistula. Saracenus, in 1642, described a fecal fistula in a 50 year old woman who had an abscess of the right lower quadrant, which ruptured spontaneously, extruding 14 lumbricoid worms. The fistula closed spontaneously. Claudius Amyand, F R S, in 1735, described a fecal fistula developing in a hernia, in which the appendix and omentum had become incarcerated. At operation, he found that the appendix had been perforated by a pin, and ligation and excision of the appendix resulted in a cure of the fistula. In 1812, Copeland observed a fecal fistula resulting from an ileocecal abscess which healed after the removal of an oval calculus from the fistulous tract. With

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Abridgment of thesis submitted by Dr. Lichtman to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirement for the degree of M S in surgery.

TABLE I.—UNDERLYING PATHOLOGIC LESION IN CASES IN WHICH FECAL FISTULA DEVELOPED AFTER OPERATION

Basic underlying disease process, condition or procedure for which operation was performed	Mayo and Schickel 1915	Rankin, Burgess, and Ross 1921		Ginsburg 1930
		Cases	Per cent	
Appendicitis	30	94	37	71
Polyp (inflammatory disease)		44	17	20
Regional enteritis				14
T. typhlocaecum, ileocecal ulcer	44	33		
Malignant tumor (intestinal or pelvic)	14	16		
Urinary colitis				
Diverticulitis			4	
Actinomycosis				
Obstructive conditions of intestine	6			
Intestinal perforation, traumatic				
Foreign body in abdomen				
Mitigation of adhesion				
External hernia				
Operation on the bile duct				
Operation for perforation of uterus				
Drainage of abscess due to "blind" diverticula				
Drainage of retroperitoneal abscess				
Uterus, removal of (and pelvic and vaginal)				
Unlabeled				
Total	1	10		

*The series presented by Mayo and Schickel included the cases observed at the Clinic from January 1901, to December 31, 1914, inclusive. This paper includes cases observed up to December 31, 1915, inclusive.

their characteristic brilliance. Bright and Addison in 1839 described the development of fecal fistulas following acute appendicitis and inflammatory lesions of the ileocecal region in those more fortunate cases in which an abscess pointed externally and ruptured spontaneously or was incised. Ginsburg in 1930 reported 14 cases of persistent fecal fistula following laparotomy in cases of regional enteritis.

CLASSIFICATION

1. *Cause.* **Congenital.** Most fistulas of congenital origin terminate at the umbilicus and represent a patent omphaloenteric duct. They are rare. None was found in this series.

Acquired. *Pathologic or spontaneous fistulas* follow spontaneous rupture of a section of the intestinal wall due to infection, malignant lesion or impeded circulation, for example perforated appendiceal abscess, diverticular abscess or strangulated hernia or in former days, typhoid fever. Internal or enterocenteric fistulas are formed in this manner. It is in this method that the body may cure for obstructions in the gastrointestinal tract spontaneously decompressing the bowel. Gastrojejunocecal, cholecystoduodenal and vesicostigmoid fistulas are examples of this type.

Traumatic fistulas include those following gunshot wounds, perforating wounds and fecal fistulas associated with compound fractures and hemorrhages (Lockhart Mummery).

Postoperative fistulas include (1) *intentional* those operatively created for decompression in obstruction to rest a diseased section of bowel or prophylactically to protect a freshly sutured bowel (colostomy, enterostomy); (2) *accidental* (Table I) those following operations involving malignant lesions, and those following inflammatory lesions of the intestines. (This is the group with which this study is primarily concerned.) The fecal fistula usually appears in the immediate postoperative period. Occasionally however there is an interval of as much as 6 to 12 months between the operation and the development of the fistula.

3. *Description of the fistulous tract* (17, 31, 13, 7, 32). **Artificial anus or lip fistula.** Intentional colostomy is of this type (Fig. 1a). There is continuity between the mucous membrane and the skin in many cases, and when a tract exists it is short. The defect in the intestinal wall is large. When the term "artificial anus" is used it implies that the entire fecal stream passes through the fistula. Many fistulas of this type have a spur or promontory (Fig. 1a') which separates the proximal from the distal loop of intestine.

Suppurative saccular fecal fistula (pyogenic fecal fistula) (Fig. 1b). Fecal or purulent material is discharged intermittently because of the interposition of an abscess cavity between the internal and the external opening. This type frequently is difficult to distinguish from

a sinus tract infected with *Escherichia coli*. Periodically, the rather small openings in the bowel will close and neither gas nor feces will pass. Recognition of this type is important because of the greater operative difficulty and poorer prognosis than in the other types. Fistulas maintained by a foreign body in the abdominal cavity are frequently of this type.

Tubular fecal fistula. A smaller portion of the feces passes through the tract than in cases of lip fistula. Tubular fistulas are single (Fig 1c) or multiple (Fig 1d) with reference to the internal or external openings.

3 *The site of termination of the fistula.*
Internal fistulas (bimucous) originate in the intestine and empty into a more distal loop of intestine, the bladder, or the genital system. **External fistulas** empty by way of the anterior, posterior, or lateral abdominal wall. The vagina or the perineum is an occasional site of exit. In the case of the **combined fistula** (Fig 1e) the tract is complex and tortuous, communicating internally with another segment of bowel or other structure and empties externally via the abdominal wall.

Some of the statistics from the literature on fecal fistula are given in Table II. Kelly and Hurdon quoted and added to Soennenberg's figures on the direction of rupture of appendiceal abscesses (Table III). Muehsam (38, 39) placed rupture into the vagina as the third most common variety. Drainage via the right fallopian tube is occasionally observed (2 cases in this series). Murphy in his clinics on fecal fistula presented a detailed description and classification of fecal fistulas. He included many unusual types of fistula.

THE INCIDENCE OF FECAL FISTULAS

Table IV gives some of the reports of the incidence of fecal fistula after operations for acute appendicitis or other abdominal condi-

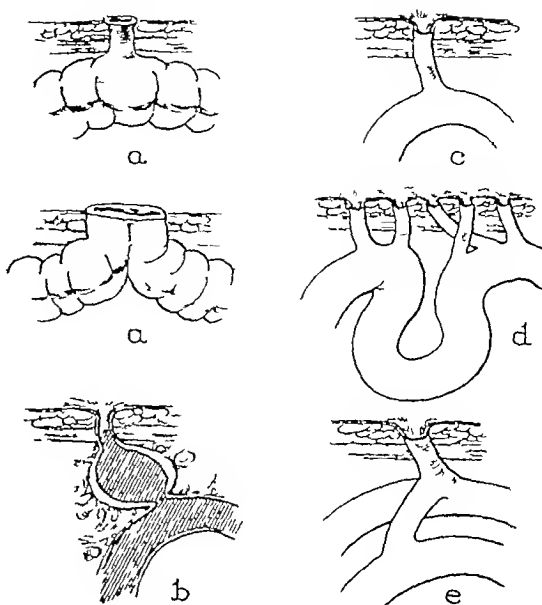


Fig 1 Types of fecal fistula. a, Lip fistula (artificial anus), a', same with spur, b, suppurative saccular (pyogenic) fecal fistula, c, single tubular fecal fistula, d, multiple tubular fecal fistulas, e, combined internal and external fistula.

tions. The series reported by MacLaren gives the incidence in 5,000 consecutive abdominal operations of all types as 1.5 per cent. When available, the percentage that healed by non-operative means is included. The figures in our series are not available, because, in the majority (93.2 per cent) of the cases, the initial operation was performed elsewhere. In Eliot's experience, all fecal fistulas occurring after appendectomy healed spontaneously. The occurrence of fecal fistulas was attributed in most cases to faulty handling of the appendiceal stump or the cecal wall. Those interested in one method of appendectomy described an added incidence with the use of other methods. Muehsam (38, 39) attributed

TABLE II —PERCENTAGES OF TYPES OF FECAL FISTULA REPORTED

Cases	Rankin and Gorder	Mayo and Schlicke
Internal	264	155
External	106	
Combined	829	
Single	719	
Multiple	609	523
	3068	281

TABLE III —DIRECTION OF RUPTURE OF APPENDICEAL ABSCESSES (KELLY AND HURDON)

	Cases
Rupture through the abdominal wall	46
Rupture into the cecum (internal)	40
Rupture into other portions of intestinal cavity	11
Rupture into the peritoneal cavity	8
Rupture into the pleural cavity	6
Rupture into the urinary bladder	3
Rupture into the uterus	1

TABLE IV.—THE INCIDENCE OF FECAL FISTULAS AFTER APPENDECTOMY AND OTHER ABDOMINAL OPERATIONS

Date	Authors	Post-operative perforation in cases of fecal fistula	Cases in series	Percent age from fecal fistula closure	Remarks
1913	Fischer				
1914	Fischer (1915)		99		Fistulas closed in all post-operative fistulas
1916	Van Lemmon				
1916	Muehsam	16	447	6	First series
1917	Muehsam	4	82		Second series
1919	Kelly and Harkin				
1923	MacLennan		1,700	84	Early too all abdominal operations
1926	Devere		4,75	26	
1926	Osborn and McNeill		1,558		
1927	Osby		4,01		
1928	Philler and O'Connell		1,068		
1931	Lewis and Smith	(1931 report)			
1932	Re		1,006	91	
1933	Ransom	8	1,077		
1937	Warner and Miller		45		Cases of regional enteritis
1938	Doley	7	47	84	

the reduced incidence in his second series to improvement in technique. While figures in appreciable numbers are not available it would seem that the widespread use of sulfonamide drugs intraperitoneally will reduce the incidence of fecal fistulas appreciably. Little attention was paid by these authors to lesions inherent in the wall of the ileum and cecum which predispose to ulceration and formation of fistula. Postoperative fistulas which develop after intervals of as much as 6 to 12 months of apparent healing were not discussed. Factors involved in formation of fistula will be discussed later in this paper.

The improved understanding of granulomatous lesions of the ileocecal region has affected the operative treatment. On finding an inflammatory adherent mass involving the terminal portion of the ileum, the cecum and the appendix, one no longer automatically assumes that the lesion originated in the appen-

TABLE V.—CAUSATION IN SPONTANEOUSLY DEVELOPED FECAL FISTULA (3 CASES)

Spontaneous perforation around caecum of sigmoid.
Spontaneous perforation of multiple abscesses of abdominal cavity of unknown cause.
Spontaneous perforation abscess diverticulae.

dix. It is recognized that in regional enteritis, the external coats of the appendix may be infected secondarily. The overwhelming incidence of appendicitis has caused surgeons to overlook regional enteritis tuberculosa, and malignant lesions of the cecum. Deaver stated that in the majority of the cases in which fecal fistulas later developed, he noticed ulcerations in the terminal portion of the ileum and in the cecum at primary operation. It is probable that in many of these cases the lesions were in reality those of regional enteritis. The more general use of conservative therapy and chemotherapy in pelvic inflammatory disease will probably reduce the incidence of fecal fistula from this cause.

Spontaneous establishment of an external fecal fistula is not common. Three such cases were encountered in this series (Table V). Haggard in 1918 reported 2 cases in which fecal fistula followed spontaneous rupture of an incarcerated hernia containing gangrenous bowel. In his 3 other cases the fistula occurred after hemorrhaphy. Muehsam (38, 39) reported 3 cases in which the fecal fistulas were created by spontaneous rupture of an abscess in the right lower quadrant.

ETIOLOGIC FACTORS IN FORMATION OF FECAL FISTULA

In Table I are given some of the larger series of cases reported which present the pathologic lesion underlying the development of fecal fistulas. Those series published previous to 1932 do not include regional enteritis as a causative factor. No doubt cases of regional enteritis were reported as appendicitis or if the lesion showed a tubercle-like formation as hyperplastic noncaveous tuberculosis. It is our purpose to study the proper relation of the latter granuloma to tuberculosis and regional enteritis. This will be reported at a later date. Because during the early years following the

TABLE VI — ORIGINAL LESION IN 408 CASES OF FECAL FISTULA OPERATED UPON AT THE MAYO CLINIC*

Basic lesion or operation from which fecal fistula resulted	Cases
Appendicitis	99
Fecal fistula after initial operation	65
Amebic appendicitis	1
Mucocele of the appendix	1
After secondary operation for obstruction	34
Regional enteritis	62†
Regional ileocolitis	9
Tubo-ovarian inflammatory disease (not tuberculosis)	49
Operations after septic abortions	3
Malignant lesions	35
Diverticulitis	28
Tuberculosis, tubo-ovarian	17
Tuberculosis, intestinal‡	17
Operations on benign lesions of uterus, tubes, or ovaries	14
Chronic ulcerative colitis	10
Operations about the gall bladder	10
Traumatic intestinal perforation, gunshot wounds, and so forth	8
In performance of herniorrhaphy	8
After multiple operations for adhesions	8
Actinomycosis	5
Miscellaneous	
Operations on volvulus, intussusception, and mesenteric thrombosis	5
Operations on benign tumors of bowel	5
Operations for repair of perforated duodenal ulcer	2
Operations on pseudomucinous cysts of ovary	2
Operations for impaction of gall stones	2
Operations for drainage of perinephritic abscess	2
Operations for resection of injured spleen	2
Operations for repair of diaphragmatic hernia	1
Drainage of subdiaphragmatic abscess	1
Drainage of prostatic abscess	1
Multiple intra abdominal abscesses of unknown cause	1
Multiple intra abdominal granulomas of unknown type	1

*Seventeen of the 408 patients operated upon had latent syphilis.

†In 42 of the cases of regional enteritis the initial operation was appendectomy or drainage of an abscess of the right lower quadrant supposed to be of appendiceal origin.

‡The term intestinal tuberculosis refers to so-called hyperplastic non-caseous tuberculosis which contains atypical tubercles but in which tubercle bacilli cannot be demonstrated or cultured.

TABLE VII — DISTRIBUTION BY AGE OF PATIENTS WITH SURGICALLY TREATED FISTULAS

Age, years	Patients
1-10	8*
10-20	35
20-30	107
30-40	90
40-50	86
50-60	55
60-70	27

*2 at age 3 years

TABLE VIII — DURATION OF FISTULAS BEFORE PATIENT CAME TO CLINIC

Time interval	Cases
0-6 months	68
6-12 months	65
12-18 months	56
18-24 months	69
2-5 years	64
5-10 years	66
10-15 years	14
15-25 years	5
45 years	1

rigid drains and blind energetic clamping

In cases in which fecal fistulas develop some time after operation, we believe that the initial step is the formation of adhesions to the abdominal wall at the site of the incision. When there is active progression of the lesion in the intestinal wall, inflammation extends along the adhesions and sets a pathway for the fistula. When there is distal mechanical or physiologic obstruction, the formation of a fecal fistula is often a saving grace. Coffey stressed the rôle played in the development of fecal fistulas by postoperative incisional hernias with adhesions to the bowel, mesenteric traction, and the resulting disorganization of peristalsis.

Heineck (25, 26) reported 3 cases in which tapeworms were believed to play a part in formation of fistula. In this series, there was 1 case in which the ova of *Taenia saginata* were observed in the wall of the fistula. Gibney described the passage of *Ascaris lumbricoides* via fistulas. In 6 of our cases, these worms were passed via the fistula, but we believe that these intestinal parasites are purely incidental. Bannick described an internal fistula following appendectomy in a case of amebic appendicitis, with a stormy postoperative course.

general acceptance of acute appendicitis as an entity, the technique of the operation, the surgical security and the rapidity of the decision to operate were less favorable than they are today, the incidence of fecal fistula was undoubtedly greater. Most of the attention and discussion were devoted to acts of commission or omission by the surgeon, rather than to any intrinsic lesions in the intestinal wall.

The literature is replete with papers attributing fecal fistulas to unintentional injuries of the intestine during operations, necrosis by ligatures and misplaced sutures, improper ligation of the appendiceal stump, the use of

TABLE IX—TYPE OF FISTULA

Type of fistula	Cases
Multiple fecal	6
Single tubular	7
Suppurative saccular (pyogenic)	35
Combined fecal	37
1 Internal fistula plus multiple external	24
Internal fistula plus suppurative saccular	
Internal fistula plus single tubular	3
Lip fistula	30
1 Internal fistula	24

Barth in 1890, reported 4 cases of fatal abdominal actinomycosis, 3 of which were appendiceal with persistent fecal fistulas. Short estimated that 1 to 3 per cent of appendiceal abscesses are actinomycotic and reported 5 cases of fatal actinomycotic appendiceal abscess with persistent fecal fistulas. Rowntree, Hinglais, and Brown also described fecal fistulas developing in cases of actinomycosis after operation. Five cases of actinomycotic fecal fistula were encountered at the Mayo Clinic in 12 years. In these cases repeated operations had been performed and one may conclude that ordinarily actinomycotic sinus tracts do not communicate with the intestine. The fecal fistula is probably a result of operative manipulation. In 21 cases of actinomycotic sinus tract of the abdominal wall in which a fistula was suspected no communication with the intestine was demonstrated.

Mucocele of the appendix is occasionally a cause of formation of fistula (Grodinsky and Rubinitz). One such case was encountered in this series. The prevention cause and treatment of fecal fistulas resulting from foreign bodies are self-evident and will not be discussed further.

STATISTICAL ANALYSIS

Five hundred and ninety patients who had fecal fistulas registered at the Mayo Clinic from January 1, 1930 to December 31, 1943 inclusive. Of these 408 were treated by some

TABLE X—SITE OF EXTERNAL OPENING

Site	Per cent
Right lower quadrant	35
Lower midline abdomen	
Left lower quadrant	
Other sites	17

The surgical treatment in 191 of these cases was reported by Mayo and Schickel. This included the cases from January, 1930, to December, 1934, inclusive.

TABLE XI—SITE OF INTERNAL OPENINGS

Site	Cases	Per cent
Ileocecal	14	3.4
Ileum	4	1.0
Terminal ileum and cecum	38	9.3
Cecum	50	12.5
Appendix		
Colon (cecal of paired)	33	8.1
Sigmoid	53	13.0
Ileum and sigmoid	8	2.0
Cecum and sigmoid		
Too complex to determine	37	9.1
Total	408	100

surgical procedure. The remaining patients did not undergo operative procedure because of medical contraindication, inadequate trial at spontaneous healing, or the decision of the patient. The nonsurgical cases were omitted from the discussion because the diagnostic data were not verified by laparotomy. Thus many of the fistulas which were believed to be single preoperatively were found at operation to be multiple and complex. There had been previous attempts at repair of the fistula in 42 per cent of the cases. One patient had had 8 previous attempts at closure of the fistula.

Table VI presents the 408 surgically treated fistulas listing as far as possible the basic lesion in the intestinal wall. When such a lesion could not be determined it was assumed that the fistula developed because of inflammation, the separation of adhesions or injury to the bowel, and the case was listed under the

TABLE XII—SUMMARY OF CASES IN WHICH FECAL FISTULAS DEVELOPED AFTER INITIAL OPERATION AT CLINIC

Cause or period of operation	Per cent
Reversion of intestinal fistula carcinoma	8
Perforation due to diverticulitis	3
Chronic diverticulitis with resection of colon	3
Regional ileitis, coincident with for	
Regional enteritis	
Regional enteritis, drainage of abscess of right lower quadrant	
After cholecystectomy	
Drainage of pelvic abscess	
After hemioleostomy	
After resection of intestine for benign tumor	
After operation for diverticulitis	
After resection for tuberculous ileitis	
Drainage of actinomycotic abscess	
Drainage of appendiceal abscess	
Total	26

TABLE XIII—POSTOPERATIVE RESULTS OF PROCEDURES FOR THE CURE OF FECAL FISTULA
ACCORDING TO TYPES OF FECAL FISTULA¹

Result	Multiple fecal		Single tubular		Saccular suppurative		Combined fistula		Lip fistula		Internal fistula		Total
	1930-1935	1936-1941	1930-1935	1936-1941	1930-1935	1936-1941	1930-1935	1936-1941	1930-1935	1936-1941	1930-1935	1936-1941	
Cured	38	47	47	39	9	10	10	13	11	5	5	10	244
Persistent	22	14	8	3	3	4	3	2	2	2	1	0	64
Died in hospital	11	4	4	2	2	1	2	0	5	0	1	1	33
Dead 1 yr	11	3	5	2	2	2	3	1	2	0	1	1	32
Inadequate follow up	6	6	5	3	3	2	1	2	2	1	2	2	35
Total													403

¹Each type is further subdivided into the cases occurring in 1930-35 and 1936-41 (6 year intervals)

Note.—Cures in cases of internal fistula and to some extent in cases of combined fistula are difficult to determine. One must depend on symptomatic recovery or roentgenologic evidence. When the operation was performed in one or more stages the result of all stages as a unit is taken

type of operation originally performed. Thus, while the appendix or a supposed appendiceal abscess was the site of the initial operation resulting in 169 of the fecal fistulas, in 70 of the cases there was found to be some other basic cause at the time of operation for the repair of the fistula. The list mentions 35 cases in which a malignant lesion was found to be the cause of the fistula. This is exclusive of intentionally created enteric or colonic stomas. Most of the cases represent operations upon the appendix or some abscess in the lower part of the abdomen in which the underlying malignant lesion was not suspected at initial operation. Internal fistula established spontaneously by malignant lesions was not included. Table VII presents the age of the patients who had fecal fistulas. The maximal incidence occurs in the third decade. Two cases occurred at the age of 3 years, both following operations for appendicitis with rupture.

The duration of the fistulas before the patients registered at the clinic is given in

Table VIII. In some cases, the fistula was permitted to drain for a remarkably long period, in 1 case for 45 years. In some, the drainage was intermittent over a period of years.

The types of fistulas encountered are listed in Table IX, with their relative incidence. Multiple fecal fistulas are the most common type. This is contrasted with the earlier group presented by Mayo and Schlicke, in which the single tubular variety was more common. It is suggested that fewer fistulas are occurring as a result of operations on acute appendicitis, and a larger percentage now occur after operations on granulomatous lesions of the intestine.

Table X presents the sites of external openings. The majority of tracts open on the right lower quadrant of the abdomen (58.2 per cent). Miscellaneous sites, such as upper part of the abdomen, posterior lumbar region, vagina, bladder, perineum, and other less common sites, occurred in 8.7 per cent of the cases.

The internal openings are listed in Table XI. The ileum is the most common site of

TABLE XIV—POSTOPERATIVE RESULTS FROM SURGICAL TREATMENT OF FECAL FISTULA
FOLLOWING SOME OF THE MORE COMMON LESIONS

Result	Appendicitis	Regional enteritis	Regional ileocolitis	Pelvic inflammatory disease	Diverticulitis	Intestinal tuberculosis	Tubo-ovarian tuberculosis
Cured	78	44	4	28	14	0	7
Persistent	4	11	3	8	9	2	7
Dead postoperatively	7	3	1	2	2	1	—
Dead 1 yr	7	2	1	7	3	3	—
Inadequate follow up	3	2	—	4	—	3	3

TABLE IX.—TYPE OF FISTULA

Type of fistula	Cases
Multiple fecal	6
Single tubular	7
Suppurative sacculus (pyogenic)	3 ¹
Combined fecal	11
Internal fistula plus multiple external	24
Internal fistula plus suppurative sacculus	
Internal fistula plus single tubular	3
Lip fistula	30
Terminal fistula	24

Barth in 1890 reported 4 cases of fatal abdominal actinomycosis, 2 of which were appendiceal with persistent fecal fistulas. Short estimated that 1 to 2 per cent of appendiceal abscesses are actinomycotic and reported 5 cases of fatal actinomycotic appendiceal abscess with persistent fecal fistulas. Rowntree, Hinglais, and Brown also described fecal fistulas developing in cases of actinomycosis after operation. Five cases of actinomycotic fecal fistula were encountered at the Mayo Clinic in 12 years. In these cases repeated operations had been performed and one may conclude that ordinarily actinomycotic sinus tracts do not communicate with the intestine. The fecal fistula is probably a result of operative manipulation. In 21 cases of actinomycotic sinus tract of the abdominal wall in which a fistula was suspected no communication with the intestine was demonstrated.

Mucocoele of the appendix is occasionally a cause of formation of fistula (Grodzinski and Rubnitz). One such case was encountered in this series. The prevention, cause and treatment of fecal fistulas resulting from foreign bodies are self-evident and will not be discussed further.

STATISTICAL ANALYSIS

Five hundred and ninety patients who had fecal fistulas registered at the Mayo Clinic from January, 1930 to December 31, 1941, inclusive. Of these 408 were treated by some

TABLE X.—SITE OF EXTERNAL OPENING

Site	Per cent
Right lower quadrant (lower midline incision)	58
Left lower quadrant	
Other sites	11.7

The surgical treatment in all of these cases was reported by May and Schickel. This included the cases from January, 1930, to December 31, 1934, inclusive.

TABLE XI.—SITE OF INTERNAL OPENINGS

Site	Cases	Per cent
Ileocecum	4	3.4
Ileum	4	34.6
Terminal ileum and cecum	38	9.3
Cecum	59	4
Appendix		7
Colon (cecal or sigmoid)	33	8
Sigmoid	35	3.5
Ileum and sigmoid	4	
Cecum and sigmoid		9
Too complex to determine	27	9
Total	408	100

surgical procedure. The remaining patients did not undergo operative procedure because of medical contraindication. Inadequate trial at spontaneous healing or the decision of the patient. The nonsurgical cases were omitted from the discussion because the diagnostic data were not verified by laparotomy. Thus many of the fistulas which were believed to be single preoperatively were found at operation to be multiple and complex. There had been previous attempts at repair of the fistula in 41.1 per cent of the cases. One patient had had 8 previous attempts at closure of the fistula.

Table VI presents the 408 surgically treated fistulas listing as far as possible the basic lesion in the intestinal wall. When such a lesion could not be determined it was assumed that the fistula developed because of inflammation, the separation of adhesions or injury to the bowel and the case was listed under the

TABLE XII.—SUMMARY OF CASES IN WHICH FECAL FISTULAS DEVELOPED AFTER INITIAL OPERATION AT CLINIC

Cause or preceding operation	Cases
Resection of intestine for carcinoma	1
Perforation due to diverticulitis	3
Chronic ulcerative colitis, resection of colon	3
Regional ileocolitis, resection of colon	
Resection of intestine	
Reoperation on enteric drainage of pouch of right lower quadrant	
After cholecystectomy	
Drainage of pelvic abscess	
After herniorrhaphy	
After resection of intestine for benign tumor	
After operation for diverticulitis	
After resection for tuberculous colitis	
Drainage of actinomycotic abscess	
Drainage of appendicitis abscess	

Total

28

TABLE XVI. COMPLICATION FOR EACH TYPE OF PROCEDURE

Complication	Extraperitoneal	Intraperitoneal	Death	Resectoperostoma	Stoma to clean terminal	Excision	Excision with Witzel	Mikulicz	Drainage of abscess	Total
General peritonitis	1	1			1	1		1		4
Shock		2			1	1	1	1		5
Illeus	1		1	1	1	1	1	1		7
Obstruction (partial)				1	1					2
Anal fistula		1	1	1	2		1	1		6
Mesenteric abscess	1	1	1	1	1	1	1			7
Drainage abscess	1	1	1	1	2				1	7
Wound infection				1	1	2	2			6
Wound-healing problem		1		1		2	1			4
Wound-healing problem		1				1	1			2
Illeus	1	1		1	1	1		1		6
Enteric fistula	1		1		1			1		4
Enteric fistula-healing problem						1	1			2
Enteritis					1					1
Phlegmon					1					1
Enteritis									1	1
Distal fistula					1					1
Obstruction				1						1
Enteritis		1		1					1	3
Mesenteric	1									1
Toileting		1		1	1	1	1	1	1	6
Total	10	11	3	5	8	61	7	24		139

um. No matter how long the period of lag, if a fistula reopened, it was considered as persistent. A lag of as much as 1½ years was encountered. Death of a patient within 1 year removed the case to that column, even if the fistula was healed at the time of death.

PATHOLOGIC ANATOMY

The gross pathology of fecal fistulas has been the subject of many studies which have provided a basis for the classification of fecal fistulas. The microscopic structure has received less attention, although much can be derived from the classic works on granulation tissue in general. Therefore, 50 cases were selected from the material available in a 12-year period for more intensive study, in order to see if any tracts showed characteristics which would account for their persistence. The 50 cases were selected, without reference to the histories, from those cases in which there was no indication in the routine patho-

logic diagnosis of any reason for the persistence of the fistula. The usual diagnosis was inflammatory or granulation tissue. Specimens in which the fistula and both its internal and external openings were easily identified were employed. In 5 of the cases before 1933 a diagnosis of regional enteritis explained the persistence of fistulas previously believed to have followed operations for appendicitis. The histories were subsequently examined and the diagnosis was verified. Characteristics were sought which would show why, without obstruction below, the usual contraction of fibrous tissue failed to close these fistulas spontaneously. Why do some of the fistulas resist repeated attempts at closure?

Repeated sections were taken at several levels of the fistula and at the opening in the bowel. The sections were stained by hematoxylin and eosin, a modified glycogen-staining carmine for amebic inclusion bodies (McNether), carbolfuchsin for tubercle bacilli, a

TABLE XV.—OPERATIVE PROCEDURE FOR THE REPAIR OF FECAL FISTULA AND THE OPERATIVE RESULTS

Procedure	Cases	Cured		Persistent		Dead postoperatively		Dead year		End-result follow up	
		Cases	Per cent	Cases	Per cent	Cases	Per cent	Cases	Per cent	Cases	Per cent
I. Extraperitoneal procedures (Quintana and Packard)	31	6	19.4	20	64.5			5	16.1	14	45.2
Simple closure	15	10	66.7					5	33.3		
II. Intraoperative procedures											
a. Simple repair with division of tract	108	77	71.3	3	2.8	6	5.6	6	5.6	10	9.3
b. Simple repair with 3-stage colostomy											
Simple repair with plastic operation on intestine	34		73	6	17.6					9	26.5
c. Simple repair with removal of pelvic viscera	37	17	45.9	2	5.4		6.2			6	16.2
d. Side-to-side anastomosis without division of tract	33		87	3	9.1			3	9.1		
e. Side-to-side anastomosis with division of tract	70	30	42.9	10	14.3	3	4.3	10	14.3	10	14.3
f. Resection of intestine and fistula with anastomosis	97	52	53.6	7	7.2	2	2.1			6	6.2
g. Resection of intestine and fistula with proximal colostomy or colostomy	26	12	46.2	5	19.2	17	65.4	7	26.9		
h. Obstructive resection (Miles)	64	30	46.9	32	50.0		3.3				
i. Colostomy only			26.6	6	23.1						
j. Ileostomy only											
k. Drainage of abscess only											
l. Exploration only	6										
m. Appendectomy only	3										
Total	417										

*Only of those done after post.
(The appendix was removed in addition to other procedures for the repair of the fistula in 14 cases. This does not include those removed during resection of the colon. Similarly, large abdominal abscesses were drained in 10 cases.)

†In 6 cases performed in the other; the colonic pouch was not closed.

origin. When the fistula is multiple and finds origin in two different segments, they are listed separately. In cases of internal fistulas, the more proximal segment is taken as the origin of the fistula and the more distal as its external opening. In 37 cases, the points of origin and exit were too complex to determine.

Table V gives the causes in the 3 cases of this series in which the fecal fistula developed by spontaneous rupture of an abscess. In 18 cases, the fecal fistula developed after operation at the clinic. These are summarized in Table VII which gives the causes or the operations after which the fistulas developed. Because of the multiplicity of the operations, no attempt was made to determine the percent age incidence represented. The remaining fistulas developed after operation elsewhere. Tables VIII, IX, X, and XI summarize the postoperative results providing the basis for the discussion of treatment. The

tables are complex. They represent an attempt to determine (1) the relative success of the operations on the various types of fistula divided into two 6-year periods (Table XIII) (2) the relative success of operative treatment of fistulas resulting from some of the more common causes (Table XIV) (3) the relative results of the various operative procedures (Table XV) and (4) the relative incidence and type of postoperative complication for each procedure (Table XVI). By this method it is hoped that rational statistical help can be obtained for the application of the proper procedure to each case. Conclusions in the section on treatment are drawn freely from these tables.

The term "cured" as employed here represents closure of the fistula as far as is determinable at the present writing, with a minimum of 9 months acceptable. Otherwise, the case is placed in the inadequate follow up col-

cular structure Although the type of cell that was predominant matched the type of cell most common in the lesion in the intestinal wall, no cell or arrangement was found to be characteristic of any of the etiologic agents observed Thus, in some cases of regional enteritis the histiocytes were prominent, in others the plasma cells and in still others the lymphocytes When more is known about the causes of these intestinal lesions, it is possible that each of these cells will represent a particular type of inflammatory response or stage in the development of the lesion

Because of the complexity of the condition, a somewhat composite picture of fistulas studied will be presented The reader should remember that in each tract one or two of the cell types and arrangements predominate The histiocytes follow the vascular structure closely Frequently they load the perivascular lymphatics, forming sheaths for the vessels At intervals, the sheaths bulge out into nodular masses, and when the nodules are numerous, they become confluent, so that the perivascular distribution is not apparent In the medial zone the vessels may form sinuses which provide the structural network of the larger histiocytic nodules Plasma cells, multinuclear histiocytes, and foreign body giant cells are associated in varying numbers In a few cases in which a large giant cell had completely surrounded a blood vessel, it was interesting to note that the vessel wall and endothelium were not visible in the portion cuffed by the giant cell Lymphatic vessels also undergo formation of sinuses

The conglomerations of histiocytes are more common at the branching of vessels and absent at the dilated curved portions The histiocytic sheath becomes thicker as the vessels approach the internal zone Where the massed capillaries form loops at the lumen of the tract, the histiocytic cells fuse and form a continuous endothelium-like layer separating the granulation tissue from the fecal stream Where regions of hemorrhage are present, the phagocytes are loaded with hemosiderin Ingested bacteria and bacteria clinging to the walls of the histiocytes are present in moderate numbers close to the lumen but are rare deeper in the tissue In recently formed

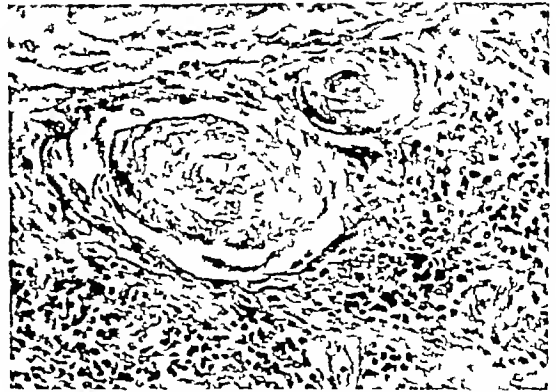


Fig. 2 The vessels of the medial zone that connect the radial branches show panarteritic changes In the small vessel the lumen is almost obliterated Medial thickening is an early change in the vessels (hematoxylin and eosin, $\times 175$)

tracts or in ulcerated regions of old tracts, polymorphonuclear leucocytes with ingested bacteria can be seen for a short distance along the perivascular lymphatics

In tracts in which lymphocytic infiltration predominates, the arrangement is less clear Large regions of the internal and medial zone are occupied by masses of lymphocytes In the medial zone, large endothelial cells with finely reticulated nuclei are intermingled True lymphoid nodules with pale central cells and a blood vessel are present in small numbers Occasionally, one sees a nodule whose center is occupied by larger cells which are endothelial in type Their fibrillar processes form a fine network in the nodule No vessel is present in these In the external zone, there are irregular masses of very deeply stained lymphocytes with very little cytoplasm Between the lymphocytes there are comma-shaped streaks of densely staining chromatin, probably representing pycnotic nuclear material

Mast cells are frequent in the areolar connective tissue, closely intermingled with the stellate fibroblasts

In the 50 tracts that were studied in detail, the predominant type of cell was tabulated Histiocytes were most common in 19 (38 per cent), plasma cells in 10 (20 per cent), lymphocytes in 7 (14 per cent), polymorphonuclear leucocytes in 1 (2 per cent), and in 13 (26 per cent) no particular cell was predominant In

modified Gram stain and Galantha's silver stain for spirochetes. Fixed frozen sections were made to study the contents of vacuoles created by solution in the lipid solvents used in making paraffin sections. Sections were studied under the polarizing microscope with and without a selenite crystal to identify doubly refractile inclusions.

Microscopic anatomy. It soon became apparent that the anatomic structure of the fistula was not haphazard but that it had a definite histologic pattern. This was established as soon as the fistula was a few months old and an organized tissue developed. While few tracts presented as clear-cut a pattern as will be described, the structure is representative of all of them. The pattern was most prominent in the fistulas that contained imbedded tale. It should be understood that the pattern is changed by frequent hemorrhage, ulceration, and overgrowth of granulation tissue in local regions.

A. The vascular pattern. This is best described by division into three concentric zones.

The external zone. The outer zone is occupied by longitudinal and circular bundles of vessels. The longitudinal vessels pass up and down the tract and are frequently limited to two regions at opposite sides of the circumference. The circular vessels branch off the longitudinal vessels and pass around the periphery of the tract. The thickness of the vessel walls is proportionate to their size.

The medial zone. The vessels in this zone run in a radial fashion. They are straight and give off relatively few branches in this zone. They run between the bundles of fibrous tissue. The branches that do exist show panarteritic changes (Fig. 2). All degrees of proliferative medial thickening and obliterative endarteritis are seen. Several vessels are completely obliterated and histiocytes invade their substance. These represent former capillary tufts which have lost their function because of the increase in amount of and contraction of the fibrous tissue tending to obliterate the fistula. In persistent fistulas elements are present which tend to slow or suppress this natural tendency. At intervals, the radial arterioles break up into sinusoid structures inside of nodular masses of inflam-

matory cells, again to form single vessels after traversing the nodule. Lymphatic vessels are also prominent both as perivascular and as independent vessels. In some fistulas sinusoid lymphatic structures surrounded by lymphocytic nodules are seen.

The internal zone. Vascular granulation tufts make up the tissue surrounding the lumen of the fistula. Capillary loops join the radial vessels. Where the capillaries curve or branch their diameter is markedly increased. At the border of the tract 3 to 5 concentric loops lie in close proximity, separated from the fecal stream by a thin syncytium of histiocyte cells. Small hemorrhages are common here and a mass of free erythrocytes and hemosiderin may be seen lying among ghosts of ruptured capillaries. Where squamous or intestinal columnar epithelium has covered the vascular tufts they maintain their structure beneath it, creating papillae and pegs or resembling intestinal villi.

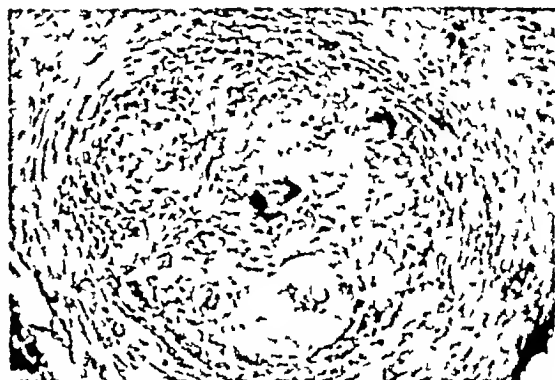
B. Fibrous tissue. At the inner portion of the medial zone stellate fibroblasts can be seen replacing the granulation tissue with a more fibrillar material. As one examines the external zone there is more collagenous material present than in the medial zone. The direction of the fibrils follows the long axis of the original early fibroblasts. In the main, the inner portion of the medial zone has circular bundles while external to this the bundles are longitudinal. The bundles in the external zone run longitudinally. Blood vessels have a fibrous sheath around them and in their early formation, early fibroblasts can be seen with their axes parallel to the vessels. The longitudinal sheaths surround the nerves and vessels outside the perineural or perivascular lymphatics.

In some cases the collagenous tissue was doubly refractile under the polarizing microscope. This may be evidence of early degeneration of the collagen fibrils. These fibrils looked normal in sections stained with bismarck and eosin and examined under ordinary light.

C. The granulation tissue. The internal portion of a fecal fistula consists of well organized granulation tissue. The inflammatory cells assume a definite relationship to the as-



Fig. 5. *Lycopodium granuloma*. a, Section stained with hematoxylin and eosin shows the spore in a foreign body giant cell. It does not stain and is highly refractile. b, This section is stained with Ziehl-Neelsen carbol fuchsin and stains bright red. c, Tubercle like formation produced by *Lycopodium*.



body was introduced by the surgeon from an unwashed glove or the perforated finger tip of a glove which so frequently is loaded with talc. The fiber-stimulating action of the silicates has repeatedly been discussed, and their action on the peritoneum has been demonstrated (Ramsay and Douglass).

In 2 (4 per cent) of the tracts the foreign body giant cells contained petrolatum producing a paraffinoma-like reaction. Looking back again, one can assume that this originated from a petrolatum gauze drain. It brings to mind the oft repeated admonition against the use of petroleum derivatives as lubricants in any body cavity, because of the occasional disastrous result.

In 1 of the tracts there was a granuloma due to the spores of the moss *Lycopodium* (Fig. 5). A tubercle like formation was noted in this case.

Four of the tracts showed ingested crystalline material which was soluble in the lipid solvents employed in embedding. In the fixed frozen section these empty spaces were identified as cholesterol esters. When the specimen was large the foreign body giant cell was seen to engulf only a portion of the crystal bundle usually the more ragged portion.

Five of the tracts showed large numbers of ingested cells in various stages of degeneration. In 3 the foreign body giant cells contained vacuoles which occupied a major por-

tion of the cells. The fluid contents were not identified. These foreign body giant cells were closely associated with blood vessels.

L. Miscellaneous and degenerative changes.
A curious observation was made on 7 (14 per cent) of the tracts. On examination with polarized light at the point of extinction multiple, minute, brilliantly refractile specks were seen. They were too small to identify and did not show any color. Some were in foreign body giant cells while others did not have any apparent reaction around them. This is mentioned because 6 of the 7 tracts showing this were among those on which operation had been performed most frequently or which had been most obstinately persistent without apparent cause. The significance of the refractile specks could not be determined.

Form cells were present in 3 of the tracts and in 5 cases were so numerous as to create xanthomatous regions. Colloid degeneration was present in 2 tracts. In 3 cases the colloid vesicles were doubly refractile and



Fig. 3 A cotton fiber in foreign body giant cell. The section (left) is stained with hematoxylin and eosin; the

section (right) is stained with modified Best carmine and the fiber stains bright red ($\times 378$).

3 tracts eosinophils were abundant. There were tubercle-like structures in 5. As has been stated, no relation between the etiologic agent and the type of cell could be established except that in 3 of the 4 cases of tuberculous included in this group the lymphocyte was the most prominent cell.

D. Contents of the foreign body giant cells. Twenty-seven (54 per cent) of the tracts contained foreign body giant cells in appreciable numbers. Study of their contents provided one of the most interesting and thought-provoking aspects of this work.

Small refractile insoluble fibers were found in 7 (14 per cent) of the tracts. In sections stained with hematoxylin and eosin they appeared to be laminated. When they were stained with carmine or methylene blue, the

outer portion stained while the central portion or core remained colorless (Fig. 3). Under the polarizing microscope they were compared with control fibers embedded in animals and definitely identified as cotton fibers. Since these were cases in which reoperation had been performed, it is likely that the fibers were initially introduced by the vigorous scrubbing, grasping and packing away of tissues with dry gauze sponges. The presence of these fibers and their possible significance in maintaining these fistulas should condemn the practice.

Furthermore, in 4 (8 per cent) of the tracts, crystals of magnesium silicate (the main component of talc) were identified by the polarizing microscope—with and without a selenite crystal (Fig. 4). Here again, the foreign

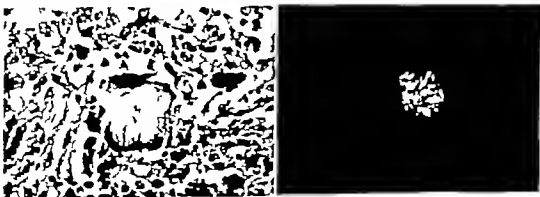


Fig. 4 Particle of talc (magnesium silicate) embedded in foreign body giant cell. The section at right shows the

same field under the polarizing microscope (hematoxylin and eosin $\times 300$).

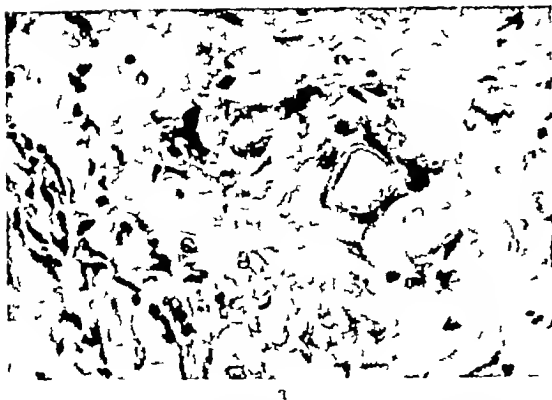
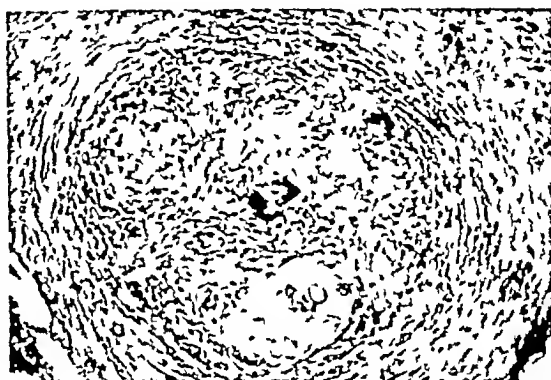


Fig 5 Lycopodium granuloma a, Section stained with hematoxylin and eosin shows the spore in a foreign body giant cell. It does not stain and is highly refractile. b, This section is stained with Ziehl-Neelsen carbolfuchsin and stains bright red. c, Tubercle-like formation produced by lycopodium



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showed clearly in polarized light. The significance of this phenomenon is not clear. It may represent early degeneration. Mucomatous degeneration was noticed in 3 tracts.

F. The lining of the tract. As has been mentioned, the granulation tissue bordering on the lumen is arranged as concentric tiers of capillary loops covered by a single layer of flattened histiocytic cells. Most of the tubular tracts maintain this arrangement in their mid sections even after years of function. The outward funnel-like advance of the intestinal epithelium is more rapid than the progress of squamous epithelium inward. Microscopically, the intestinal epithelium advances in small outlying crypts in which the deeper parts are covered by young columnar cells while the exposed portions still maintain their histiocytic covering. When completely covered, the granulation tufts show a superficial resemblance to intestinal villi. The squamous epithelial border, however, is sharper with a heaped-up margin and a short slope of advancing cells. When the granulation tufts are thus covered a resemblance to pegs and papillae is found. While contact is found in lip fistulas and intentional colocolic stomas, no tubular tract of any length was encountered in which the squamous epithelium actually contacted the intestinal epithelium. In hemorrhagic and in suppurative regions no lining of the tract was seen. The tissue lining the tract in the 50 cases was as follows: histiocytic 23, cecal 8, squamous and cecal separated by histiocytic section 6, squamous, 4, ileal 2, squamous-cecal (lip) 2, histiocytic with section of suppurative membrane 2, degenerating fibrous tissue 2, and suppurative membrane 1.

The external border of the tract which separates it from the peritoneal cavity is composed of a rather acellular compact layer of fibrils. Such cells as exist are poorly preserved, pyknotic and difficult to distinguish. It could not be clearly determined whether they were histiocytes, xerous cells or fibroblasts.

G. Nervous tissue elements. In 10 (20 per cent) of the tracts nerve fibers and ganglion cells were found to have extended into the tract. This occurred only in those tracts in which the associated intestinal lesion showed marked hypertrophy of the nerve bundles and

myenteric plexus. Although slightly more common in cases of regional enteritis, this hypertrophy seemed to represent another phase of the reaction of the intestine in chronic inflammation. The hypertrophy of nerve tissue seemed to be most marked in those cases in which there was an exceptionally excessive production of fibrous tissue. In these tracts nerve bundles and ganglionic cells were found for as much as 5 centimeters from the intestinal end of the fistula. In other cases large cells containing pale blue cytoplasm with immense reticulated nuclei and clear interreticular spaces were seen. It could not be determined whether these were of neurogenic or endothelial origin.

FACTORS WHICH MAINTAIN FISTULAS

Most fistulas in which there is not obstruction in the bowel below or specific infection or malignant lesions to maintain them close spontaneously. Some, however, are obstinately persistent and defy repeated attempts at closure. It is in this group that we are particularly interested.

Senn stated that the mucosal lining of fistulous tracts prevented their healing. Kelly and Hurdon attributed the failure of closure of the tracts to rigid fibrous walls, also claiming that fistulas from the ileum were rare. Coffey in an extensive study discussed the rôle of herniation in the abdominal wall in the maintenance of fecal fistulas. Von Mikulicz and Kausch and Fergue attributed great importance to the peristaltic traction on the afferent and efferent intestinal loops and traction of the mesentery against the adhesions to the abdominal wall. Agreeing with Coffey's views, Lewis and Penick added the factor of intra-abdominal pressure in the maintenance of fistulas and the production of spurs. They stated that long tortuous tracts tend to heal spontaneously. In Deaver's experience however, such tracts usually required operative closure. Erdmann and Hansom stated that tracts originating in the ileum tended to persist.

In this series a hernia of the abdominal wall was noticed in 3.3 per cent of the cases. It must be remembered that these patients registered at the clinic after prolonged hospitalization.

and drainage from the original wound, after long persistence of the tract, and in 42.1 per cent of the cases after repeated attempts at closure elsewhere. In the material studied here the following reasons for persistence of the fistula were found:

1. There is a distinct, active lesion in the intestinal wall at the fistulous opening which prevents spontaneous closure. Operative closure can be successful only if this diseased segment is excised.

2. Foreign substances such as cotton fiber, talc, lycopodium, petrolatum, and products of degeneration embedded in the fistulous tract itself may alter the processes necessary for spontaneous closure of the fistula.

3. The defect or diseased portion in the intestinal wall may be too large for spontaneous closure, since contraction of scar tissue sufficient to close the fistula would produce constriction of the intestinal lumen. Here also resection of the diseased though quiescent segment of the intestine is essential for closure of the fistula.

THE DIAGNOSIS OF FECAL FISTULAS

The diagnosis of external fecal fistulas is made apparent by the nature of the discharge. In cases in which the external opening is small, sinus tracts infected with *Escherichia coli* can simulate the fecal discharge. In such cases feeding of insoluble or indigestible substances easily identified in the discharge establishes the connection with the bowel. In fistulas which discharge intermittently the passage of gas indicates a small opening in the bowel. A careful history is essential to the diagnosis. The presence of a foreign body must be ruled out.

When the diagnosis was in doubt, Judd suggested the injection of bismuth petrolatum paste into the tract. With repeated roentgenography one may determine the loss into the bowel. In present-day practice many radiopaque substances are available. To determine the site of origin of the fistula Senn advised injection of hydrogen gas with auscultation over the cecal region. If the gas escaped quickly without a gurgle, it indicated a fistula from the large intestine. If escape occurred after an interval with gurgling as the

gas passed the ileocecal valve, the fistula originated in the small intestine.

The diagnosis of internal fistulas taxes the ingenuity of the physician. Careful roentgenoscopy with barium in the intestine will usually give suggestive evidence. The function of intentionally created anastomoses is commonly studied in this manner. With unusual fistulas special investigations are performed. Pool and Miller discussed the diagnosis of vesicoappendiceal fistulas. In their case catheterization of the tract by cystoscopy with the injection of an opaque medium demarcated the connections. In fistulas associated with the genital tract, the simultaneous use of barium in the intestine and injection of a radiopaque substance by catheterization of the external opening may be used for diagnosis. Thus by barium enema and hysterosalpingography one may outline an appendicosalpingeal fistula. Sigmoidoscopy is useful in diagnosis of fistulas originating in the sigmoid. By this method the internal opening was brought into view in 14 of the cases studied. While it may seem academic to subject the patient to such studies when the diagnosis is obvious, these methods give important preoperative information as to the condition of the intestine at the opening of the fistula, its function and, most important, the patency of the intestine distal to the fistula. In complex multiple and combined fistulas the diagnosis of connections is difficult even after direct observation at laparotomy.

Because of the poorer prognosis and more difficult operative treatment of suppurative saccular fecal fistulas it is wise to establish the diagnosis beforehand. These patients give a history of intermittent feculent and purulent discharge depending on the patency of the communication between the intestine and the abscess cavity. In this series it was noted that the only cases of fistula in which there was a history of hemorrhage from the tract were of this type. In 6 cases the amounts of blood were small, while in 3 cases the hemorrhages were severe.

Further, one must mention the lag that frequently occurs between operations and the development or recurrence of fecal fistulas in cases of regional enteritis. Periods of apparent

healing for as much as 6 to 12 months after appendectomy or repair of fistula performed in such cases were noted. Development of a fecal fistula after obvious healing of the incision following appendectomy should suggest the possibility of regional enteritis.

TREATMENT

Discussion of the treatment of any surgical complication properly begins with a plea for prevention. Reduction of the incidence of postoperative fecal fistulas should follow greater understanding and recognition of the lesion in the intestine, application of the proper procedure and surgical care, the intra-peritoneal use of sulfonamide drugs in the presence of inflammation and realization that finely divided substances like cotton fibers, talc, lycopodium and petrolatum may produce granulomas in the peritoneal cavity.

The management of fecal fistulas at the Mayo Clinic has been described by Dixon and Deuterman, Schlicke and Dixon, and Mayo and Schlicke. Much that is written here is a recapitulation of these articles.

Spontaneous healing. Spontaneous healing of most postoperative fecal fistulas will occur. The larger series report spontaneous closure in from 39 per cent (Denver) to 91 per cent (Ray) of the cases. Several smaller series report 100 per cent spontaneous closure after operations for acute appendicitis (Elliot). Experience has taught that a 6 to 12 month trial at spontaneous closure should be allowed before any operative treatment. Gage (quoted by Kelly and Hurdon) described a fistula which closed spontaneously after 7 years of drainage. The greater the length and the more tortuous a fistula, the greater is the tendency toward spontaneous healing. These same characteristics tend to make the operative dissection more difficult. Before one proceeds on a trial of conservative therapy, presence of a foreign body in the tract should be ruled out for in such cases operative removal is essential to a cure.

Nonoperative measures which promote healing. 1. For higher intestinal fistulas, more fluid the drainage from the fistula, greater is the debilitation of the patient producing many problems during the peri-

observation. The loss of electrolytes, enzymes, and nutritive material alters the normal economy of the body and necessitates replacement of essential substances by enterostomy or by intravenous and subcutaneous therapy. The closer the fistula is to the duodenum the greater is the threat to life.

Continuous suction by any one of a number of ingenious methods is of threefold benefit: (1) It promotes healing by keeping the fistula empty and collapsed. By slight reduction of the intestinal pressure it promotes a more normal status and may tend to reduce the flow of intestinal juices and the accelerated emptying time of the stomach. (2) It prevents excoriation of the skin by the trypsin and other intestinal contents. (3) It provides a simple method of estimating the loss of fluid and electrolyte by measuring the fluid aspirated. In an occasional case the fluid can be returned to a distal loop of bowel. The suction devices described are numerous and often make use of common household items such as coat hangers and pouring caps from sugar dispensers. In any device a small opening in the fenestrated tube should be outside the stoma, preventing adhesion of the wall of the tract and the accumulation of excessive suction.

Dixon and Deuterman employ a well made of kaolin and adhesive plaster. Other authors advise the use of milk protein, olive oil, and egg white in the diet to provide a menstruum for enzymes and bile present. Surface excoriation is further prevented by the local application of beef broth and Witte's peptone, milk powder, aluminum powder or paste, spraying with 0 per cent tannic acid or the application of tenth normal dichloric acid. When

tritive value, fluid, electrolytes, and nonexpendable substances in the fecal stream have been absorbed, and the hazards are diminished during the trial at spontaneous closure. The incidence of spontaneous closure in this region is greater than in more proximal segments of the intestine. A high caloric, low residue diet is fed and the volume of fecal drainage is diminished. If the skin is indurated, 5 per cent sulfathiazole in a heavy petrolatum base or aluminum paste or powder may be employed. Many devices for plugging the fistula were employed formerly. Beck's bismuth paste was abandoned, because of the danger of bismuth poisoning. There are still occasions for the use of chewing gum, iodized oil, or iodoform gauze. Marshall and Lahey, in 1938, described a simple double button device. Before the employment of any of these, inflammation must be excluded; hence they should never be used in the treatment of suppurative saccular fistulas. They may be used when the patient is a poor surgical risk and is losing ground and are occasionally successful in healing a fistula in which the discharge is small and intermittent.

Preoperative care. Before operation the patient's protein, carbohydrate, electrolyte, fluid, blood, and vitamin reserves are evaluated and readjusted. A nonresidue diet is given. The patency of the bowel beyond the fistula is again established. In inflammatory lesions maximal subsidence of the inflammation is secured by rest in bed. Although sufficient experience is not yet available, it appears that preoperative oral administration of 2 to 4 grams of succinylsulfathiazole 6 times a day for 3 days is of distinct value in the more complex fistulas. Sodium phosphate catharsis for 2 days before operation is common. Colonic irrigations with saline solution in the knee chest position and irrigations via the fistula, if possible, are given for several days. The condition of the skin may be improved by 5 per cent sulfathiazole ointment. Maceration or induration of the abdominal skin should be cleared up before an operative incision is attempted. In high intestinal fistulas the prothrombin time should be determined and vitamin K administered, if indicated. The patient should be in as good condition as possible in

preparation for a difficult operation with a high incidence of failure and a formidable mortality rate.

Surgical treatment. The presence of a fistula with an unknown course and having an indeterminate number of internal relations prevents any surgical approach with a preconceived idea. By the very nature of the development of the fistula, laparotomy is bound to present a field distorted by adhesions and the surgeon must possess a knowledge of facts concerning the chances of cure and respective mortality rate for each etiologic lesion causing fistulas. Thus in the cases presented here the rate of recurrence after attempt at repair in each category was as follows: postappendectomy, 40 per cent, regional enteritis, 17.8 per cent, diverticulitis, 31.0 per cent. A common cause for failure in these operations lies in the failure to close all the openings in the intestine. Even after extensive resections an obscure internal fistula resembling an adhesion will cause a persistence of the fistula.

A. Extrapentoneal procedures. 1. Curettage and packing. Indications for this procedure are as follows: (1) when biopsy is carried out, (2) when a foreign body is suspected, (3) when the patient is too debilitated for any more extensive procedure, or (4) when it is believed that a little freshening will promote granulations and contraction where the tract is well lined by epithelium. It is not very effective (28 per cent cures) and is usually successful only in hastening the course in a fistula that already shows signs of closing. It was the only procedure in 19 cases between 1930 and 1935, while between 1936 and 1941, although it was performed many times, it was the total procedure in only 2 cases.

2. Simple closure—extrapentoneal (Smith and Coffey). This is the simplest closure. Here the skin around the stoma is freed and the walls of the fistula are dissected away from the abdominal wall. A probe may be used to delineate it; otherwise it is plugged or closed to prevent contamination. The dissection is carried down to the peritoneum, which is pushed back so that the fistula can be clamped and excised with the knife or cautery. The fistula is excised with a longitudinal incision

in the intestinal wall. The mucosa is inverted with 2 or 3 rows of sutures in a transverse direction. Five grams of sulfathiazole are dusted in the area and the abdominal wall is closed in layers. A drain may be inserted down to the fascia. This method is in wide use in the closure of intentional colonic stomas after the spur has been crushed. It is the procedure of choice in some cases of fistula. Marshall and Labey advised its use when the fistula is thin and small and the internal opening is small. When the skin is in poor condition the closure of the skin can be postponed. The method possesses certain inherent disadvantages. It is difficult to judge the extent of the lesion in the intestinal wall, the presence of adhesions or small internal fistulas or encroachment on the lumen by narrowing or kinking, and to maintain the blood supply after suturing. If the opening of the fistula is antimesenteric, the latter reason is not important. The procedure is less successful in cases of regional enteritis, for the fistulas are frequently intramesenteric and there is a chance of including essential vessels in the sutures. This method brought about effective closure in 62.8 per cent of the cases it was employed in.

B. Intrapertoneal procedures: 1. Simple intraperitoneal repair with excision of the fistula. This procedure was performed in 108 cases. With its modifications it is the most common procedure applied, but resection methods have recently gained in use. Incision was made at the operative site (Rigby) or less frequently at the remote site (Lockhart Mummery). The fistula is excised and the intestinal wall closed under direct inspection (Dixon and Deuterman). In this method as in all intraperitoneal methods the lesion in the bowel, the adhesions, the blood supply, encroachment on the lumen and any unrecognized internal fistulas can be evaluated. Five to 10 grams of sulfathiazole should be scattered over the repair and in the wound. Placement of drains depends on the induration and swelling. This method was effective in closing the fistula in 69.2 per cent of the cases in which it was attempted.

In 9 additional cases a Witzel enterostomy was performed to protect the repair of the internal opening. The addition of this safe

guard is dependent upon the surgeon's sense of caution. The comparative value is difficult to judge because the procedure is employed only in the more difficult cases.

2. Simple repair with plastic operation on the intestine. In 16 cases it was considered advisable to excise a wedge of intestine because of the presence of a lesion in the intestinal wall through which it was not safe to place sutures. Care must be exercised to maintain the blood supply to the antimesenteric border by excising a 45 degree acute angle even if good bowel must be sacrificed. This method was effective in 75 per cent (12) of the 16 cases it was employed in, but the fistula persisted in 1 case (6.3 per cent). There were no deaths in this group. It represents the best results obtained by any method, but the number was not adequate for any definite conclusions. However it suggests that a common reason for failure in simple closures is that the inverting sutures are placed in diseased intestinal wall.

3. Simple repair with resection of pelvic viscera. This procedure was performed in 32 cases. Most of the cases represent fistulas following incision or attempted excision of a tubo-ovarian abscess, in which a suppurative saccular fistula existed. The procedure was attended with great difficulty in many cases. In some cases dense adhesions made hysterectomy or salpingo-oophorectomy essential in the repair of the fistula. The method was successful in 33.2 per cent of the cases it was performed in.

4. Side-to-side anastomosis without excision of the fistula. This was the definitive operation in 38 cases, of which 8 per cent were successful. It is a partial diversion operation frequently of palliative nature and not the operation of choice. It cuts off or reduces the amount of feces that passes through the isolated loop of bowel and thus it provides rest for that segment. When there is an intrinsic lesion of the intestine this is of moderate value as is evidenced by the frequent progress of ulcerative colitis and regional enteritis when the fecal stream is diverted. When the excision of a segment of bowel containing multiple fistulas is beyond the skill of the surgeon it is the safest procedure. In 25 of the more

difficult cases of this series ileocolostomy was performed as the first stage of a more extensive procedure preparatory to the subsequent resection of the terminal portion of the ileum, the cecum and the ascending colon

In 19 additional cases diversion anastomosis together with the simple excision and closure of the fistula was performed Detailed discussion of variations of this operation has been given by Keyes and Middleman They referred to the partial diversion by anastomosis of the proximal and distal segments as a lateral anastomosis They also described a unilateral exclusion and a bilateral or complete exclusion operation In the former, the proximal segment is divided, shutting off flow through the affected portion and leaving a blind segment containing the fistula (This was performed 7 times in this series) However, reflux discharge may occur in the stump They favored the bilateral (complete) exclusion operation, in which the side-to-side anastomosis is done in a clean field away from the fistula and both the distal and the proximal loop are severed and closed From the condition of the patient, the advisability of the immediate resection, subsequent resection or permanent retention of the excluded segment and fistula can be judged If the closed excluded segment is left in, it will not cause any symptoms Fistulas connected with segments of the colon usually close spontaneously Blind segments of ileum secrete small amounts of chyme, but in Rigby's experience even these may close

5 Resection of the bowel and fistula with anastomosis This was performed in 97 cases There were 59.8 per cent of cures with a mortality rate of 8.2 per cent In many cases added internal fistulas had to be closed simply In 27 cases the procedure was done in two stages In an additional 26 cases a proximal Witzel enterostomy or colostomy was performed This is the operation of choice when there are multiple fistulas and adhesions, or when any plastic repair would cause narrowing of the lumen of the bowel The cases represented here are mainly those in which there was regional enteritis or ulcerative colitis, or in which there had been numerous previous attempts at repair Rigby and Keyes and

Middleman expressed the opinion that this is a formidable procedure, to be used only in extreme cases However, despite the fact that this method was applied in cases in which the fistulas were most complex, the mortality rate and percentage of cures compare favorably with those of any other method employed on complex fistulas

6 Extraperitoneal resection (obstructive resection, Mikulicz) This was performed in 24 cases with a mortality rate of 8.3 per cent Cures were obtained in 41.7 per cent of the cases In 4 cases closure of the colonic stoma was followed by a persistent fistula and in 4 others closure of the stoma was not attempted because of disease of the intestinal wall In this operation the diseased segment of the intestine containing the fistula is exteriorized The operation is of unquestionable value in lesions of the large intestine and it is a frequently employed method of treatment of such lesions even when no fistula exists The lesions situated in the sigmoid are commonly accompanied by marked obstruction Marshall and Lahey, as well as Keyes and Middleman, are enthusiastic about this method and extend its use to the small intestine They employ it in cases of fistula resulting from regional enteritis However, closure of the stoma in the small intestine is attended with greater difficulty than closure of a colonic stoma and care of an enteric stoma is more annoying to the patient than care of a colonic stoma

7 Other procedures Colostomy alone was performed in 14 cases and ileostomy alone was performed in 4 cases The rate of cure is small (28.6 per cent for colostomy) but the procedure is indicated when the patient's condition is too poor to allow a more involved operation In 7 cases the only procedure that could be done was drainage of an intra-abdominal abscess The operation terminated in simple exploration in 6 cases Appendectomy was the only procedure in 5 cases The results of these procedures are not quoted separately because they were palliative and not directed at the cure of the fistula

Deaths within 1 year after operation are given in all the tables even if the fistula was closed at that time In most cases they are

THE EFFECT OF CERTAIN DRUGS ON THE MOTILITY OF THE JEJUNOILEUM IN NORMAL MAN

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INTESTINAL movements in normal man have been studied by means of the x-ray and the kymograph to determine the reaction of the intestine, especially the colon, when a system of balloons connected with a recording device is introduced into a colostomy. The action of several drugs has also been studied by the same method.

Aside from radiologic observations, the motility of, and pharmacodynamics on, the jejunum are little known. Orr and Carlson (1926), Dorack and collaborators (1931), Abbott and Pendergrass (1936), and Ingelfinger and Abbott (1940) studied the action of morphine by means of intubation. Elson and Drossner observed the effects of atropine, belladonna, benzedrine, and pitressin by the same method (Elson, Glenn, and Drossner, 1939). Forster studied the effects of morphine (1938) and of morphine and atropine (1940) on the longitudinal and circular muscle fibers of an exteriorized loop of small intestine. By means of a system of balloons introduced into an ileostomy, Guthrie and Bergen (1936) observed the effects of pitressin, physostigmine, peristaltine, and acetylcholine, on the small intestine. In the same way Adler, Atkinson, and Ivy (1942) studied the action of morphine and dilaudid, and Schwartz, Reingold, and Necheles (1942), that of prostigmine.

The object of the present work is to determine the action of amyl nitrite, glyceryl trinitrate, theophylline ethylenediamine (cardiomin Collier), methyl octenylamine (octinum Knoll), and diphenyl diethylaminoethanol hydrochloride (trasentin Ciba), and to study more thoroughly the effect of pitressin, prostigmine, morphine, and atropine, on the jejunum of normal man.

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METHODS

The studies were carried out in 11 male volunteers who presented no clinical evidence of digestive disease. Their ages ranged between 23 and 55 years. One subject was studied twice.

After 10 hours of fast, the subjects swallowed the Miller-Abbott tube (1934) until its tip lay $2\frac{1}{2}$ to $4\frac{1}{2}$ feet below the pylorus. The presence of the tip in the small intestine was checked by x-ray. At the end of the study the position of the tip in the ileum was again determined by x-ray. The end of the tube connected the rubber balloon at the tip with a Marey tambour. A pressure of 25 centimeters of water (Ingelfinger and Abbott, 1940) was applied to the apparatus. By a separate opening in the tube it was possible to remove fluid which accumulated above the balloon.

When the tip had reached the duodenum, the subject drank 250 cubic centimeters of milk, 2 hours before the tracing was started. He took 300 grams of clear soup. While the tracing was being made the subject lay motionless on his back.

The kymographic record was begun at least 15 minutes before the administration of drugs. In each subject the effects of several drugs were studied serially, the complete disappearance of the effects of the previous drug was always awaited before a new one was given.

RESULTS

A. Intestinal motility. The movements recorded from the use of a balloon subjected to a pressure of 25 centimeters of water are very irregular. They consist of small (Fig. 1), medium (Fig. 1), and large waves (Figs. 2, 6a, and 8a). The small waves have a frequency of 5 to 10 per minute, the medium ones, 2 to 3 per minute, and the large ones, once per 1 to 3 minutes.

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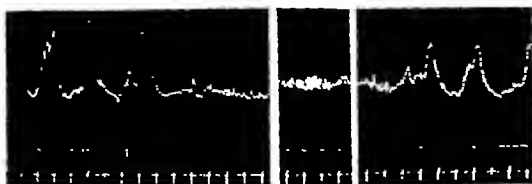


Fig 5 Action of methyl octenylamine in J M aged 45 years. Balloon was $2\frac{1}{2}$ feet below the pylorus a, left, Signal indicates time of injection of 100 milligrams of methyl octenylamine subcutaneously. Movements prior to injection are type III b, center, 11 minutes after a, c, right, 11 minutes after b

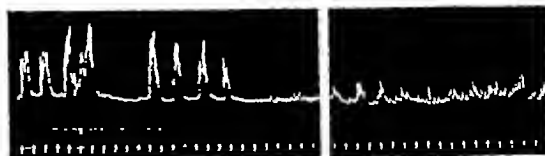


Fig 6 Action of diphenyl diethylaminoethanol hydrochloride in P H, aged 55 years. Balloon was 4 feet below the pylorus a, left, Signal indicates time of subcutaneous injection of 0.075 gram of diphenyl diethylaminoethanol hydrochloride. Movements prior to injection are type III b, right, 49 minutes after a

slower than that seen following the use of amyl nitrite

E Methyl octenylamine Methyl octenylamine (octinum Knoll) injected subcutaneously in doses of 100 milligrams produced, in the 4 volunteers studied, a great decrease in the intestinal movements, only small waves of type I variety were noted and at times these disappeared. In 2 cases the tonus fell significantly during the period of action of the drug, in the 3d patient a less distinct fall in tonus was noted, while in the 4th none at all was noted (Fig 5). The effect of this drug began 5 to 17 minutes after injection and lasted 38 to 66 minutes. Recovery was slow. After the effects of the drug seemed to have worn off, the motility did not return to the type noted before the use of the methyl octenylamine in general the movements afterward were type I or a combination of types I and II.

In the hands of Atkinson, Adler, and Ivy (1943), octinum injected in doses of 100 milligrams or given by mouth up to 300 milligrams did not change the activity of the large intestine during 2 hours of observation.

F Diphenyl diethylaminoethanol hydrochloride This drug (trasentin Ciba), in doses of 0.075 gram given by deep subcutaneous injection, produced effects similar to those of octinum. In the 4 volunteers used, the tonus fell, though not markedly, in 2 the volume of the contractions decreased enormously, so that, as may be seen in Figure 6, the movements almost disappeared. Recovery was slow (Fig 6), and the rhythm of movement was different from that seen before the drug was given. The action began 3 to 17 minutes after the injection and lasted 88 minutes. In 1 case this drug merely lowered almost im-

perceptibly the tonus of the intestine, this experiment lasted 75 minutes.

Jackman and Barger (1938) studied the action on the movements of the large intestine when the drug was given slowly by vein in a dose of 0.05 gram. They observed a decrease in tonus and a decrease but not a disappearance of the wavelike activity. Atkinson, Adler, and Ivy (1943), injecting intramuscularly 50 to 100 milligrams or giving 75 to 225 milligrams by mouth, noted a decrease in tonus and in some cases (35%) a decrease or an absence of the movements of the colon, in 14 per cent of their observations they did not find this decrease. In 1 case in 5, these authors found that trasentin rendered the movements of the large intestine more regularly rhythmic.

G Pitressin In 8 volunteers we injected subcutaneously in doses of 4 to 10 units pitressin prepared in the Instituto Bacteriológico de Chile (Hipofisina). These doses produced a clear fall in the base line (Fig 7) and a change in the peristaltic movements, which became gigantic type II waves. Often a certain rhythm was maintained, or the irregular movements which had preceded the injection became more regular. These gigantic waves coincided with abdominal pains of a colic-like nature, between them there was a relative absence of intestinal motility. Figure 7 exemplifies the action of this drug. The effects began $2\frac{1}{2}$ minutes after subcutaneous injection.

Similar results were obtained by Elson, Glenn, and Drossner (1939). They found decrease of tonus in the jejunum but increase in the ileum. In both segments large waves appeared and the small ones disappeared. In the terminal ileum Guthrie and Barger (1937)

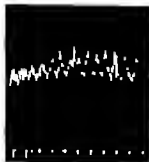


Fig. 1. Intestinal motility J. M., aged 41 years. Balloon as $\frac{1}{2}$ feet below the pylorus. Intestinal movements at left of figure are type I, those at right are type III. (In this and subsequent figures time is marked in minute intervals; in the originals the drum moved 6 millimeters per minute. Balloon pressure, 25 centimeters of water.)

Fig. 2. Intestinal motility in E. M., aged 50 years. Balloon was $\frac{1}{2}$ feet below the pylorus. Type III motility

Among these waves may be distinguished the three types of motility described by Terapleton and Lawson (1931) and by Adler, Atkinson, and Ivy (1941 and 1942), for the large intestine of dog and of man, namely, types I, II and III (Figs. 1, 2, 5a, 6a and 8a).

In our 12 observations the 3 types of motility were combined in 6 persons: types I and III were combined in 3 cases, types I and II were associated in 2 cases and a single type, type I, appeared in only 1 person. Type I can be said to predominate, having been present in all 12 cases; next comes type III, in 9 of 12 cases and finally type II in 7 of 12 cases.

In the normal individual therefore the movements of the jejunum differ from those of the large intestine. In that type II waves predominate in the latter (Adler, Atkinson, and Ivy 1941). In addition, type III waves of the small intestine last 1 to 3 minutes as compared to the 5 minutes described for the colon (Adler, Atkinson and Ivy 1942).

Effects of Drugs

A Amyl nitrite. Amyl nitrite was inhaled until flushing appeared. In every case studied (4 cases) there occurred a marked fall in intestinal tone and disappearance of motility (Fig. 3) or at least a considerable decrease in the volume of the contractions. This phenomenon appeared as soon as the general effects of the nitrite began and lasted about a minute



Fig. 3. left. Action of amyl nitrite J. M., aged 45 years. Balloon was $\frac{1}{2}$ feet below the pylorus. Signal indicates moment of inhalation of amyl nitrite.

Fig. 4. Action of theophylline ethylenediamine in J. M., aged 45 years. Balloon as $\frac{1}{2}$ feet below the pylorus. Between the two signals, an intravenous injection of 0.24 gram of theophylline ethylenediamine was given.

except that in 1 case the decrease both in tone and amplitude of contractions lasted $2\frac{1}{2}$ minutes.

Jackman and Barger (1938) studied the action of this drug on the colon. They also observed a definite decrease in tone and an absence of contractions. Their results differ from ours in that in their series the effect lasted 3 to 5 minutes and was followed by a slow recovery; in our observations the longest period was $2\frac{1}{2}$ minutes after which there was rapid recovery to the same type of activity shown previous to the administration of the drug (Fig. 3).

C Glyceril trinitrate. Jackman and Barger (1938) administered 0.6 milligram of nitroglycerine under the tongue and obtained a decrease of tone in the colon lasting 20 to 50 minutes, an action less intense but longer lasting than that following the use of amyl nitrite. We used an alcoholic solution of nitroglycerine (1%) recently prepared. It was administered under the tongue in doses from 3 to 10 drops (0.5 to 1.66 mgm.). No effect was seen in the kymograph records of any of the 4 subjects, despite repeated attempt in each case.

D Theophylline ethylenediamine. Theophylline ethylenediamine (cardioline Collier) in doses of 0.24 gram by slow intravenous injection, produced a definite fall in tone of the ileum in the 4 persons studied even before the full dose had been injected. The intestinal movements were type I throughout the period of activity of the drug and in 3 of 4 cases the waves became much smaller (Fig. 4). Four and one-half minutes was the longest period of effectiveness of the drug and recovery was

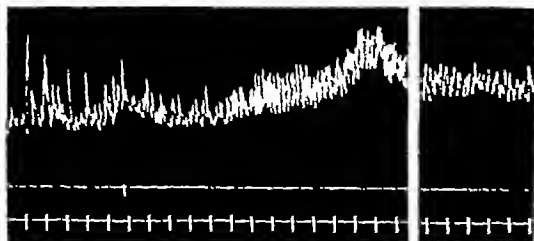


Fig 9 Action of morphine in P H, aged 55 years. Balloon was 4 feet below the pylorus. a, left, Signal indicates time of subcutaneous injection of 0.01 gram of morphine sulfate. b, 16 minutes after a.

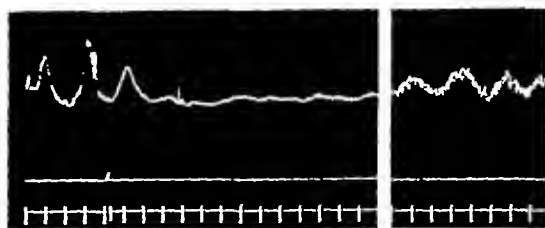


Fig 10 Action of morphine in F C, aged 23 years. Balloon was 3 feet below the pylorus. a, left, Signal indicates the time of subcutaneous injection of 0.02 gram of morphine sulfate. b, 20 minutes after a.

Our results do not differ from those recorded by these various authors. In 4 subjects, morphine sulfate in doses of 0.8 to 2 centigrams injected subcutaneously produced a decrease in amplitude of the intestinal movements (Figs 9 and 10) until they almost disappear (Fig 9). The action begins between 3 and 8 minutes after the injection. In half of our cases morphine decreased the tonus and, in the other half, increased it (Fig 10).

In the large intestine, Bergen and Jackman (1939) demonstrated an increase in tonus, peristalsis, and amplitude of contraction. Adler, Atkinson, and Ivy (1943) described, in the majority of their experiments, an increase in the nonpropulsive activity and of the tonus, with loss of the propulsive activity. In one of the segments of the colon they found a decrease in tonus and an increase in the frequency of contraction. The same authors had published similar results the previous year.

ANALYSIS OF STUDY

The method described herein is the only one available which permits the graphic study of intestinal movements in a normal person. It is far from ideal, however. The type of movement depends on the pressure in the system (Welch, 1937) to this factor we attribute the absence of periods of inactivity of the small intestine which are demonstrated by means of other techniques (Forster, 1940). Moreover, one cannot distinguish between the types of activity which are contributed by the circular and by the longitudinal muscle fibers.

Another disadvantage of the method is the difficulty of keeping the balloon in the same

segment, despite fixation of the external end of the tube, the intestinal end of it may move to a more distal segment because of the activity of the intestine during the period of the study (about 5 hours). Aside from this, the lower segments exhibit less motility (law of intestinal gradient of Alvarez, 1940).

The pressure in the balloon depends not only on the activity of the intestine itself, but also on changes of intra-abdominal pressure due to muscular contractions in the abdominal region, conditions which impede the registration of intestinal movements during vomiting or other conditions producing an increase of intra-abdominal pressure.

All our subjects were given a small meal before the tracings were made, partly to keep the intestine as near to the normal state as possible, and partly to prevent fatigue of the subjects due to the long duration of the experiments (8 to 10 hours) and the action of the various drugs which were used on them.

Templeton and Lawson (1931) and Adler, Atkinson, and Ivy (1941 and 1942) described various types of movements in the intestine of dog and man. According to them, type I corresponds to nonpropulsive intestinal activity, and type II corresponds to a wave of activity usually propulsive, the predominant type of movement of the colon. Contrary to Adler, Atkinson, and Ivy (1941 and 1942) we have seen type I in the jejunum of the normal man more often than type II. If the latter wave represented propulsive activity of the intestine it should be observed more frequently in the small intestine, for this type of motility is more characteristic of this segment of the intestine (Alvarez, 1940).



Fig. 7. Action of pitressin in J. M., aged 45 years. Balloon 4 1/2 feet below the pylorus. Signal indicates time of subcutaneous injection of 5 units of pitressin. Arrows indicate moments at which subject had colic-like abdominal pains.

noted that pitressin produced large waves every 1 1/2 to 3 minutes, beginning 3 minutes after injection and lasting 55 minutes.

The effects of pitressin on the colon are much like those on the ileum (Guthrie and Barger 1936; Adler, Atkinson, and Ivy 1942; Atkinson, Adler, and Ivy 1943).

II Prostigmine Prostigmine (prostigmine methylosulfate, Hoffman-La Roche) in doses of 0.5 milligram subcutaneously produced effects after 13 to 18 minutes which lasted until 80 minutes after the injection. In 3 of 4 volunteers it increased the amplitude of the contractions (Fig. 8). In 1 case of the 4 there was a discrete fall of tonus with no other effect during the 53 minutes of observation. In 1 person in whom the intestinal movements had been type III the waves became larger and appeared at greater intervals than before the use of the drug.

Schwartz, Reingold, and Necheles (1942) observed an increase in motor activity of the small intestine when this drug was used. Adler, Atkinson, and Ivy (1942) and Atkinson, Adler, and Ivy (1943) using the same dose as we had used, observed the same results as we did in reference to the colon but the effect was more intense. They saw in all cases an increase in the propulsive and general activity of the large intestine the effect beginning 20 minutes after the injection of the drug and lasting 1 to 2 hours.

I Atropine sulfate One milligram of atropine sulfate injected subcutaneously decreased



Fig. 8. Action of prostigmine in P. H. aged 55 years. Balloon 4 feet below pylorus. a, left, Signal indicates time of subcutaneous injection 0.5 milligram prostigmine; b, center 7 1/2 minutes after; c, 9 minutes after b.

slightly the tonus of the intestine. The waves were smaller and if they had been type II or III they changed to type I. The same dose of atropine injected after pitressin caused the disappearance of the large waves described in section G. Our results agree with those described by Elson and Drossner (1939) in regard to the small intestine. Atropine causes a decrease in tonus of the large intestine (Jackman and Barger 1938) and may even cause the spontaneous motor activity to disappear (Atkinson, Adler and Ivy 1943).

J Morphine sulfate Previous results in reference to the action of morphine sulfate on the small intestine have been contradictory. Orr and Carlson (1926) and Dvorack and collaborators (1931) found that the usual clinical doses of morphine increase the peristaltic activity of the small intestine but that larger doses (Orr and Carlson 1926) decrease the activity without changing the frequency of the contractions. On the other hand Abbott and Pendergrass (1936) observed an increase in the contractions in addition they describe an increase in tonus and a decrease in amplitude. This effect was followed by a depressor action which lasted several hours and could be the only visible effect in the ileum. Forster (1918 and 1940) using a different technique confirmed the results of Abbott and Pendergrass (1936) in regard to the action of morphine on tonus and frequency; he also called attention to the suppression of the propulsive activity. Adler, Atkinson, and Ivy (1942) found that morphine in the majority of cases increased the tonus and amplitude of the contractions but that there are cases in which it has no effect or may decrease the tonus. Moreover, Abbott and collaborators (1943) observed a rise of basal intraintestinal pressure by the action of this drug.

on one side, (2) severe pain on inspiration, (3) cyanosis, (4) dyspnea, and (5) shifting of the mediastinum. If, however, the temperature and pulse did not subside, or tended to increase, or if the patient showed an anxious expression, aspiration was done for bacteriological examination of the fluid. All chest wound patients were given large doses of sulfathiazole orally for the first week after entering the hospital. If the temperature were normal at the end of that time, the sulfathiazole was discontinued, but if the temperature remained elevated above 1 degree, the sulfathiazole was continued in smaller doses. Empyema did not develop in any case.

GAS BACILLUS INFECTIONS

We have had 35 cases of gas bacillus infection. All had clinical gas gangrene, confirmed bacteriologically. Four deaths occurred from gas bacillus infection, 3 of the patients who died had thigh wound infection and the 4th had an abdominal wound infection.

All but 2 of the patients who had gas bacillus infection were given Parke-Davis combined gas gangrene antitoxin. A thorough débridement was done in all cases in which gangrene was not present. Amputation was done in cases of gas bacillus infection with thrombosis of the artery and gangrene. All wounds were dusted with sulfanilamide crystals at time of operation, and wounds were packed open with vaseline gauze. Plasma, transfusions, and fluids were given intravenously as indicated.

Gas bacillus infection did not develop in any case in which a thorough débridement was done. All wounds had been dusted with sulfanilamide in the field and most patients had received sulfathiazole by mouth.

Our experiences at this hospital have shown beyond doubt the value of the application of sulfanilamide in the wound and of sulfathiazole by mouth. The drugs should be given directly after the wound occurs and also following débridement. This combination of sulfonamide therapy seems to have prevented the development of infection in contaminated wounds.

TREATMENT OF COMPOUND FRACTURES

Transportation. Patients were transported to this hospital by Marine and Army Air trans-

port planes. Transportation to and from air fields was by standard Army and Navy ambulances. In the latter campaigns, as the line of battle went northward, transportation from the outlying islands was by landing ship, tank craft, from the battle line to a developed air field where air transport was available. In the Guadalcanal campaign transportation time averaged 6 to 8 hours, most casualties arrived within 24 to 36 hours from the time they were wounded. In the New Georgia campaign transportation time averaged 4 to 7 days from time of wounding. Distances varied from 500 to 1000 miles by air transport. A few casualties were taken directly from ships, which had received them in transfer from warships at the scene of battle. Air transport of more than 7 hours was too strenuous even for patients with slight wounds. No ill effects from altitude were noted on any fracture patients even after severe hemorrhage had occurred. Most patients on admission were worn out from long transportation, the lapse of time, and pain. They were usually hungry because messing facilities were often inadequate, particularly during the early phases of the Guadalcanal campaign. Most men were dehydrated.

Splinting. The majority of patients with fractures of the long bones were received with the fracture fixed in a Thomas or Keller, hinged, half-ring (Army) splint. In many of the earlier cases traction hitches applied over the shoe or foot had caused deep pressure sores over the dorsum of the foot and the tendo achillis. It is believed that adhesive skin traction should be used instead and that no traction hitch should be allowed to stay on for more than 3 to 4 hours without adjustment. A few patients were admitted with board splints. Many were admitted with plaster slab support for both upper and lower extremity fractures. A few compound fractures of the femur were admitted in plaster hip spica casts. These patients without exception were more comfortable, less tired, and had less fever than those to whom splints were applied by traction and Army splint. Patients with extreme swelling, hemorrhage, or suspected gas infection could not, of course, be so transported. Heavy plaster slabs in most compound fractures (except those of the femur)

upon by the cineplastic method enabling the amputee to utilize the remaining muscles in the stump to operate a prosthesis along natural lines. The double arm amputee must live in a different world. He is helpless and requires assistance even in the minor pursuits of life. In 1 of 2 such cases a cineplastic amputation was performed on one forearm. On the other forcipization was done, the stumps of the radius and ulna being used as fingers.

TABLE I—SUMMARY OF FRACTURES FROM
MAY, 1942, TO OCTOBER, 1943

	Cases		Cases
Total number of patients with compound fractures	615	Radius	53
Multiple fractures	144	Ulna	44
Total number compound fractures	880	Metacarpal	57
Clavicle	16	Phalanges (hand)	67
Ribs	50	Femur	80
Vertebrae	11	Tibia	86
Scapula	26	Fibula	52
Pelvis	25	Patella	10
Humerus	66	Tarsals	50
		Metatarsals	89
		Phalanges (foot)	68
		Carpals	30

HEAD AND SPINAL INJURIES

Patients with head injuries comprised the largest group treated in the neurosurgical service. Many of the Army patients were admitted with the diagnosis of contusion, but were in reality neuropsychiatric problems. Compound fractures of the skull provided the largest part of the operative work. There were 33 patients admitted with a compound fracture of the skull, and 25 of these were operated upon. One of the operative patients died, he had also sustained multiple wounds and an amputation of one leg had been done because of a gas bacillus infection. One patient with a compound basilar fracture died as the result of a severely lacerated cortex. Another patient died from the effects of a shrapnel fragment which penetrated his mid-brain. None of the patients with a compound fracture of the skull showed evidence of meningitis while in this hospital. The dura appeared to be intact in 5 of the 25 patients who came to operation. The average interval between the time of injury and operation was 5.68 days, the longest interval being 20 days and the shortest 1.5 days. A few cases of simple fracture were observed. Three patients

struck by falling coconuts and rendered unconscious were treated, none showed evidence of skull injury or residual brain damage.

Patients with spinal injuries were handled by both the orthopedic and neurosurgical services. In only 1 gunshot wound of the spine was operation carried out, a laminectomy was performed in the dorsal region and a shrapnel fragment was removed from the substance of the cord. The patient was operated upon 5 days following injury, and during the 2 weeks he was observed following operation no infection was apparent.

Patients with severe spinal cord injuries were treated with oral sulfadiazine, forced fluids, special care to pressure points, change of position every 4 to 6 hours (by rolling them carefully on a sheet), and the use of oral mineral oil, and enemas when needed. Bladder care consisted of the employment of an indwelling catheter, this being clamped off except for drainage every 3 or 4 hours. Although all patients with this bladder regimen showed evidence of cystitis and urethritis, no case of clinical pyelitis was encountered.

Little peripheral nerve surgery was done because of the hesitancy to bury silk in grossly contaminated wounds.

Patients admitted with the diagnosis of concussion, if found on examination to have no abnormal neurological findings, were handled by the neuropsychiatric service.

Patients with intracranial injuries without any associated scalp and skull injuries, were kept in bed from 10 to 21 days, with mild elevation of the head, given adequate fluid intake, and aspirin (with or without codeine) for control of headache. Spinal punctures were not done routinely, but were done when the extent of the cerebral injury was in doubt and when a change in the condition of the patient merited an examination of the spinal fluid.

One patient with a middle meningeal hemorrhage (extradural) was encountered and was operated upon approximately 3 hours after he fell from a truck. The bleeding was controlled by a suture through the dura with ligation of the vessel, and the clot was evacuated and a decompression done. Recovery was uneventful.

Three patients with subdural hematomas were seen, the hematomas were evacuated and

areas has become apparent. After cleansing the various methods of treatment are available. It is recommended however that all burns be treated as open wounds. Fine mesh sterile gauze impregnated with petrolatum or vaseline is used as a primary layer in the dressing. A smooth, thick layer of sterile gauze is applied over this, and held in place by a smooth, evenly applied bandage. Firm pressure is important, as it minimizes the loss of serum. When possible splinting of extremities is advised. If no complications ensue, dressings are left in place for 10 to 14 days, after which most first and second degree burns will have healed. Unless fever or odor from the dressings, or excessive purulent discharge indicate infection and contamination even original first aid dressings may be left in place for the 10 to 14 day period. When first aid dressings are removed in the hospital it is advised that the medical officer and all assistants be masked, and that the burned area be treated always as an open wound. Third degree burns should be prepared for grafting by excision of all dead tissue. If suppuration is present, further preparation is of course, necessary. However wherever full thickness skin loss has occurred skin grafting should be carried out at the first possible moment.

Management of infected cases. Immersion baths in warm saline solution are an invaluable aid in cleansing discharging surfaces of secretions and debris. The patient is immersed in a tub when practicable twice daily for an hour or more depending upon his condition. In those necessarily confined to bed, hypertonic saline soaks are of value. Wet saline dressings, moistened at frequent intervals, are applied over raw infected surfaces after the application of sulfanilamide dusting powder to control spreading of the local infection.

In patients manifesting secondary anemia, transfusions of citrated blood in 500 cubic centimeter quantities, given as frequently as necessary to bring the blood count to a satisfactory level are used. Heavy doses of vitamin C and thiamin chloride to supplement a high vitamin, high protein diet are given.

Other methods of treatment. These include spraying with gentian violet (2 per cent aqueous solution) spraying with triple dye

1 per cent sulfanilamide in mineral oil 1 per cent sulfathiazole ointment (this has been found to be as effective as stronger concentrations) and boric acid ointment dressings (not recommended in the tropics because of chemical changes in the boric acid).

Tannic acid in aqueous solution, in jelly or in a spray combined with silver nitrate is no longer used at this activity. However inasmuch as a tannic acid jelly was the only agent available to us in the treatment of 91 cases from May 1942 to May 1943 its application was our principal method in the management of these burns. Briefly our cases were divided into two types: clean cases received within 24 hours from the injury and infected cases, in which more than 24 to 48 hours had elapsed since the burn. Clean cases were debrided in the operating room under anesthesia when necessary. The debrided surfaces were sprayed with sulfathiazole powder by means of an ordinary nasal atomizer then covered with a thin layer of tannafax jelly applied with an ordinary sterile wooden tongue blade. The patient was then placed under a heat cradle formation of a thin eschar occurred quickly. Infected burns were handled as open wounds, saline immersion baths were used and the wound was covered with sulfathiazole ointment. In both the clean and infected cases, healing of first and second degree burns occurred with satisfactory rapidity, third degree burns were necessarily individualized, secondary debridement being done often when demarcation of necrotic tissue was manifest.

Since results were so uniformly good with this method it was not felt necessary to depart from this routine. The thin, flexible eschar or so called tannic crust provided many advantages in the handling of these patients among them should be mentioned early relief of pain by sealing over exposed nerve endings elimination of the necessity for drainage prevention of serum loss and the evacuation of patients when necessary with greater facility. We are still of the opinion based on our own experience that the sulfathiazole powder spray under a thin flexible tannic acid eschar deserves its proper place in the armamentarium of burn therapy.

WOUND DISRUPTION

A Study of 55 Cases at the Cincinnati General Hospital
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IN recent years numerous studies of abdominal wound disruptions have been made. Jenkins in 1937 summarized the literature upon the subject, collecting a total of 1,683 cases, of which 389 were reported by Hinton were not included. Singleton and Blocker and Hartzell and Winfield (16) in 1939 published additional data supplementing Jenkins' statistics which, with other series reported since that time (3, 9, 18, 30, 40), raise the total of abdominal wound disruptions reported in this country to approximately 720 cases.

A review of the operating room files of the Cincinnati General Hospital for the 10 years beginning January, 1933, shows that there were 55 eviscerations of laparotomy wounds during that period. It is realized that this figure may not represent all cases of evisceration which occurred during this period, since some patients who suffered this complication may not have been treated surgically, while others may have undergone secondary suture on the wards.

DEFINITION

The term "disruption" as employed in this paper will refer to those cases in which any portion of the peritoneal cavity or its contents presented in the wound. Among the words used as synonyms for this condition by various authors are dehiscence, rupture, eventration, evisceration, avulsion, and separation. During the 10 years between January 1, 1933, and January 1, 1943, 8,346 laparotomies and 2,150 elective herniorrhaphies were performed in this clinic. The distinction between laparotomies and herniorrhaphies is made because (1) no eviscerations occurred in the latter group, and (2) certain investigators (7, 26) include herniorrhaphies in calculating the incidence of wound disruption. If the incidence of

wound disruption is based on the total of 8,346 laparotomies, the percentage is 0.65 per cent, whereas should herniorrhaphies be included the percentage would be 0.52 per cent. A comparison of our statistics with those of other clinics is presented in Table I.

TABLE I — COMPARISON OF STATISTICS

	Total cases	Number of disruptions	Per cent
1933-1943	8346	55	0.65
Cincinnati General Hospital	2750	26	0.54
1934 Colp	7892	17	0.22
1936 Koster and Kasman	3234	8	0.24
1936 Glasser†	9000	61	0.67
1939 Singleton and Blocker*	6532	33	0.5
1939 Hartzell and Winfield†			
1941 Hesselstine and Bohlender†	3179	15	0.47

*Elective herniorrhaphies not included in calculations
†It is not definitely stated that herniorrhaphies were included

The distribution of our cases over individual years was as follows: in 1933, 7 disruptions, in 1934, 4, in 1935, 4, in 1936, 7, in 1937, 3, in 1938, 2, in 1939, 5, in 1940, 9, in 1941, 2, in 1942, 12.

These figures might suggest the influence of certain variables as the following: changes in technique, suture material, different surgeons, and preoperative and postoperative management. It is thought by some, however, that variations from year to year could be within the realms of chance. Thus Maes and his co-workers collected 44 cases of wound disruption over a 10 year period, the distribution of which, as compared with our cases, is shown in Table II.

Maes stressed that in the 13 cases of disruption occurring in 1933 operation was performed by 13 different surgeons for 13 varieties of diseases. Milbert also emphasized the rôle of chance, stating that 6 of the 30 cases which he collected occurred during a 2 week period. Bettman and Lichtenstein and Schmitz and Beaton have also commented on the sporadic occurrence of wound disruptions. In the 2 cases which occurred at this hospital in 1938

TABLE II.—COMPARISON OF CASES OF WOUND DISRUPTION

Maes, Berman, and McFetridge Year	No. of disruptions	Chesmond Year	General Hospital No. of disruptions
1924	5	933	7
1925		934	4
1926		935	4
1927	7	936	7
1928		937	3
1929		938	
1930		939	5
1931		940	9
1932	5	941	
1933	5		

operation was not performed by members of this visiting or resident surgical staff.

The distribution of the 55 cases by services was as follows: general surgery, 43; gynecology, 8; obstetrics, 1; operated on outside: 1, Police Fire Department, 2.

The age distribution is listed in Table III.

The youngest patient in this group was 36 hours of age. No younger case could be found in the literature. The other patient in this first group was 6 weeks of age. The oldest patient was 72 years of age. The average age for the entire group was 48.3 years. It is noted that 47 cases occur in the decades between 30 and 70. The majority of workers, including Colp, Singleton and Blocker, Kross and Glasser, place the most common ages for disruption between 30 and 50. In the series collected by Maes and his co-workers, 65.6 per cent of the disruptions occurred in patients between 10 and 40 years of age. The distribution in our group corresponds to the observations of McFetridge and Howes, Milbert, and Koster and Kasman (36).

Most investigators agree that age is not a factor and that the seeming preponderance of disruptions in the years between 30 and 50 years is explained by the fact that the major portion of a given hospital population falls within these limits.

TABLE III.—AGE DISTRIBUTION, OUR SERIES

Age	Number of disruptions	Per cent
0-9		1.6
10-19		
20-29	3	5.4
30-39		20
40-49		30
50-59		8
60-69		1.6
70-79	1	5.4

Of the 55 cases in our group, 40 were males and 15 were females. It is generally believed that the sex of a patient does not influence the incidence of wound disruption. A few authors as Milbert and Colp, however, believe that males are more subject to wound disruption than females because of (1) abdominal breathing, (2) greater physical activity, (3) less elasticity of abdominal wall than females, (4) greater use of alcohol and nicotine. No opinion that women are more prone to wound disruption can be found in the literature.

Of the 55 cases in our series, 14 or 25.4 per cent were in negroes. This figure is of little significance since it is not known what percentage of patients submitting to surgery were of that race.

Boland studied the incidence of evisceration in negroes. Over a 10 year period during which 4,337 laparotomies were performed there were 12 eviscerations, or 0.28 per cent. The author concluded that the condition occurred less frequently in negroes than in white patients. It was suggested by Boland that the predisposition of the negro to keloid formation may be a factor. Although Maes and his co-workers also found that dehiscence occurred less frequently among negroes, in their series, these authors believed that race was not a factor. Furthermore Baldwin, Kennedy, Koster and Kasman (36) and others have published reports in which the studies were not confined to negroes, and in which the incidence of wound disruption was less than that reported by Boland.

Of the 55 cases in our study, 33 or 60 per cent occurred in winter or spring. Sokolov, reviewing cases occurring in northern Europe, stated that eviscerations were more common in winter and spring. This finding was attributed by the author to the scarcity of fresh vegetables in the diet during these months with resultant tissue deficiencies.

Maes and his co-workers and Colp thought that seasons had no influence the former stating that the dietary problems of northern Europe cannot be compared to those of the United States.

Hartzell and Winfield (17) reported 20 disruptions from November through April, and 13 from May through October. The difference

TASHIRO WOUND-DISRUPTION

was ascribed by these authors to a greater incidence of upper respiratory infections during the winter months

PRIMARY DISEASE

Debility Many authors have discussed the influence of certain diseases and constitutional conditions upon the incidence of evisceration. It is felt by some that the healing power of tissue is impaired in such conditions as diabetes mellitus, pernicious anemia, cholecystic disease, peptic ulcer, carcinoma, tuberculosis, general debility, and syphilis.

Hartzell, Winfield, and Irvin (17) have presented convincing data in support of certain phases of this theory. The data will be considered later.

Briefly reviewing our series. As regards concomitant disease there were 12 cases of carcinoma, 2 of tuberculosis, 1 of pernicious anemia, 12 of peptic ulcer, 8 of cholecystic disease, and 10 of systemic or central nervous system syphilis and no cases with diabetes mellitus, a total of 42, or 79.2 per cent of the group.

Colp believes that generalized debility resulting from either the primary disease or associated conditions is the major cause of post-operative wound disruption. Sokolov in his exhaustive work directed attention to the fact that many of the 723 cases which he collected occurred during the years of starvation or dietary deficiency following the last World War.

Heyd and Starr and Mason independently expressed the belief that debilitating influences are the primary cause of evisceration in a restricted group of cases.

At the other extreme are the proponents of the belief that primary disease or associated debilitating conditions play no part in evisceration. Glasser and Cave stress that prompt healing occurs in many patients suffering with wasting diseases and emphasize the usual uncomplicated rapid healing which follows secondary closures of wound disruptions.

Koster and Kasman (26) also dismiss primary disease or concurrent debilitating conditions as not contributory.

Habitus Of our series, 10 patients (18.1 per cent) were described as obese, 16 (29.0 per

cent) as poorly developed and poorly nourished, 20 were well developed and well nourished, while the habitus of 9 was not described. Milbert cited the theory of Livingston in regard to the relation of habitus to intra-abdominal pressure. It was the belief of the latter that the intra-abdominal pressure of obese individuals was greater than normal because of the presence of increased mesenteric intraperitoneal and abdominal wall adipose tissue. The author believed that in cachectic individuals, wasting of the tissues of the abdominal wall reduced the ability of that structure to withstand and absorb shock. Hume, also cited by Milbert, observed in normal individuals an increase in the intra-abdominal pressure of from 100 to 150 millimeters of mercury with descent of the diaphragm and contraction of the abdominal muscles. Should one consider the change in intra-abdominal pressure resulting from post-operative complications as distention, cough, singultus and emesis, the theory of Livingston cannot be disregarded.

Of the 55 cases in our series 54 operations were performed by 26 surgeons. The operator in the remaining case was not known. Two surgeons each had 5 cases of wound disruption.

PRIMARY OPERATIONS

The primary operations are presented in Table IV.

TABLE IV — PRIMARY OPERATIONS

	No of cases	Percent
Biliary tract	8	14.5
Gastric resection	7	12.7
Closure ruptured peptic ulcer	5	9.0
Supravaginal hysterectomy	5	9.0
Salpingoophorectomy	4	7.2
Gastroenterostomy	2	3.6
Gastrostomy	2	3.6
Exploratory laparotomy—including	12	21.8
Volvulus		
Tuberculous peritonitis		
Retroperitoneal hematoma		
Intestinal obstruction (2)		
Carcinoma of large bowel (2)		
Carcinoma of stomach		
Stab wound of abdomen		
Miscellaneous—including	10	18.1
Splenectomy		
Instrumental perforation sigmoid		
Ramstedt pyloroplasty		
1st stage Whipple (2)		
Transverse colostomy		

Anesthesia The types of anesthesia employed at the primary operation were distributed in the following manner: spinal 5 (9.0 per cent), local 9 (16.3 per cent) and general 39 (70.9 per cent). Of the latter 2 were begun under spinal and 1 under local anesthesia. The type of anesthesia used in 1 patient operated upon at another hospital is not known.

It is difficult to demonstrate a definite relationship between wound disruption and the type of anesthesia used at the primary operation.

Koster and Kasman (16) reported 3,234 patients who were operated upon under spinal anesthesia in 0.22 per cent of whom evisceration occurred. It is not known whether femoral and inguinal hernias were included in this series. The authors stated that spinal anesthesia afforded maximum relaxation and ease of exposure and closure.

Milbert reported 1,500 patients (excluding inguinal and femoral hernias) operated upon under inhalation anesthesia in whom there was evisceration in 1.28 per cent.

Colp does not believe anesthesia to be a factor. Glaxier and Eliason and McLaughlin noted that the often uncontrollable behavior of patients attending a premature cessation of anesthesia may result in undue strain.

Maes, Boyce and McFetridge wrote that faulty anesthesia could be considered as contributory to only 1 of their 44 cases of wound disruption.

Incisions The operative incisions employed in the cases under consideration were distributed in the manner shown in Table V.

TABLE V.—OPERATIVE INCISIONS

Incisions	Disruptions	Per cent total
High right rectus		43
High left rectus	7	7
Low left rectus	3	5.4
Low right rectus		8
Midline umbilicus to pubis	9	5.3
Left rectus (level not specified)	5	9
Right rectus (level not specified)		8
Transverse	4	7
✓ record	3	5.4

The correlation of operative incisions and eviscerations is discussed by many authors.

Most investigators are convinced that upper

abdominal incision disrupt with greater frequency. Sigalas, Freeman and Starr and Mason dispute this point. Kross does not believe that the site or type of incision is a factor.

Vertical upper rectus incisions are thought by many to be more likely to disrupt because they are not anatomical. Such incisions transect the normally transverse fibers of the posterior rectus sheath, the predominantly transverse elastic fibers of the skin and the vascular and nerve supply in this region. Furthermore because of the coatal attachments of the anterior abdominal wall a marked lateral stress is induced by common postoperative strains as cough, emesis, distention, and singultus.

Cave suggested that rectus splitting incisions result in the atrophy of a strip of muscle. Labey condemns the midline incision as predisposing to accumulation of serum between the bellies of the recti.

Colp, however, has closed 231 upper midline incisions (the majority were cases of gastric disease) with through and through black silk sutures only without dehiscence.

The so called anatomical transverse incision is favored by Whipple and Elliot. Singleton and Blocker describe a modified Sloan incision and report 292 vertical upper abdominal incisions with 9 eviscerations against 470 transverse upper abdominal incisions with no eviscerations. Meloney and Howes, Grace and Koster and Kasman (16) have reported eviscerations through transverse incisions. It will be noted that 4 of the disruptions in our series occurred through transverse incision. Six of the 44 eviscerations reported by Maes, Boyce and McFetridge occurred through McBurney incisions. The latter also reported evisceration occurring after repair of a direct inguinal hernia.

Drains Of the series under survey only 9 (16.3 per cent) patients were drained, 7 of these through a stab wound lateral to the operative incisions and only 2 through the operative incisions. The fact that a wound has been drained suggests often that there had been more than the normal amount of exudate or operative manipulation and implies a stormier postoperative course.

Singleton and Blocker reported the incidence of evisceration in drained and undrained wounds as 1.99 and 0.59 per cent, respectively, while Colp making a similar comparison, submitted 1.22 and 0.84 per cent.

Cave reports 21 cases of postoperative hernia following drained McBurney incisions and none following 282 undrained wounds of the same type. Boland, Maes, and his co-workers, Hartzell and his co-workers (16) have suggested that drains may establish an avenue of protrusion for omentum or bowel. Glasser, however, claims that there is but a single case to be found in the literature in which evisceration occurred through a drainage tract. Meleney and Howes believe that drains are too often used, and observed that "in many cases of established infection of the peritoneal cavity drains do very little good." Jenkins states that continuous sutures should not be placed contiguous to drains because of the possible erosion and severance of the former.

Primary closure As can be expected, the methods of closure varied considerably. A rough tabulation of the type of closures employed is given in Table VI.

TABLE VI — TYPES OF CLOSURE

Type of closure	No of cases	Percent
All catgut with exception of skin	24	43.6
Silver wire through and through	6	10.9
All silk	10	18.1
Combination of silk and catgut	10	18.1
No description available	5	9.0

In the majority of cases, regardless of the type of suture used, the abdomen was closed in layers with interrupted figure-of-eight sutures. In reviewing the cases, one concludes that no method of closure is prophylaxis against evisceration.

The method of closure advocated by most authors is the use of plain or chromic catgut for peritoneum and fascia, nonabsorbable sutures for the skin and stay sutures of silk, dermal, silkworm gut or wire. The catgut used for the closure of the rectus sheath is generally of the No. 2 chromic variety used as a continuous or interrupted suture. Meleney and Howes believe that No. 0 chromic catgut is of adequate strength, stating that the holding power of the sutured tissues, including the

rectus fascia, does not exceed the tensile strength of No. 0 chromic catgut. Whipple prefers the use of fine silk in clean wounds.

Hinton and Kennedy use through-and-through sutures of silkworm gut. Hinton believes that some patients are allergic to catgut while Kennedy believes that all buried sutures act as foreign bodies and ligatures.

Kennedy and a senior associate have used through-and-through silkworm gut sutures for 56 years without a single disruption. His only departure is the use of fascial mattress sutures of silk in cases of hernia.

Hinton, however, cites 2 cases of disruption which occurred with this type of closure. Baldwin reports 16,485 cases without a single disruption in which the closure was as follows: (1) continuous No. 2 chromic catgut in peritoneum, (2) reversed through the rectus muscle, (3) reversed and locked in the fascia, (4) three silkworm gut stay sutures, (5) continuous catgut No. 2 sutures for the skin.

Postoperative strains It is the opinion of most investigators that postoperative strains are either a primary or secondary cause of evisceration. After a review of our records the incidence of some of the more commonly implicated postoperative strains were tabulated (Table VII).

TABLE VII — POSTOPERATIVE STRAINS

Contributory causes	No of cases	Per cent of total
Cough	38	69.0
Distention	24	43.6
Emesis	24	43.6
Wangensteen suction}		
Gastric lavage }	18	32.7
Abdominal cramps	7	12.7
Mental confusion	14	25.4
Singultus	3	5.4
Bronchial asthma (severe)	1	1.8
Out of bed	5	9.0
Tried to get out of bed	2	3.6
Bladder distention	1	1.8

Glasser believed unusual postoperative strains to be the sole cause of evisceration. Whether primarily or secondarily a factor, their rôle in evisceration is seemingly important since the force of sudden intra-abdominal strains apparently can cause silk to tear through fascia and also result in rupture.

A point of some interest is the fact that 11 patients who eviscerated were encouraged to

cough. These 11 cases occurred during the past 3 years. No record of this method of prophylaxis against atelectasis is found in the nursing notes prior to 1940 although it was undoubtedly used.

Anemia and plasma protein vitamins. In recent years much attention has been directed toward the significance of anemia hypoproteinemia and vitamin deficiency in wound disruption. These factors will be considered in that sequence.

Since the Tallqvist method was used in many hemoglobin determinations and since hematocrit determinations were performed on only 8 patients, the findings of anemia are not too accurate. Should one consider 4 and 3.25 million cells per cubic millimeter as expressing significantly subnormal red cell counts in the male and female respectively and 12 and 10 grams per 100 cubic centimeter for similar hemoglobin levels, 24 (43.6 per cent) of the 55 patients were anemic at some time during their hospitalization. The red blood count and hemoglobin determinations of 21 (38.1 per cent) patients were normal throughout their hospital stay. A total of 10 (18.1 per cent) patients apparently had no red cell counts or hemoglobin determinations during their course in the hospital. Of the 24 patients considered anemic during some phase of their hospitalization 11 did not receive transfusions of blood or plasma.

Anemia, plasma protein vitamin C. Only 4 patients had plasma protein and hematocrit determinations before operation although 36 of 55 cases were elective. The findings in the 4 cases were normal.

Four patients had plasma protein and hematocrit determinations after the primary operation. In all of these the plasma protein determination was below 6.25 while the hematocrit was normal.

Seven patients had plasma protein and hematocrit determinations following disruption. In one group of 7 cases, 4 patients exhibited normal plasma proteins with hematocrit readings below 35 in 3 while the remaining 3 were characterized by plasma protein levels below 6.25 and normal hematocrit readings.

In our series of cases 2 patients received vitamin C before the first operation 6 re-

ceived the preparation before the second operation, and 12 after secondary closure.

Thompson Ravidin and Ingalls performed investigations upon dogs and demonstrated that in hypoproteinemic states there was acceleration in the absorption and decrease in tensile strength of catgut. These authors noted that experimental wounds in hypoproteinemic animals showed gross edema, a pallor and an unhealthy appearance with a minimum of bleeding and finally the presence of serous fluid. Microscopically there was (1) a minimum of fibroblastic proliferation (2) an increase of intercellular fluid. Of 11 animals with hypoproteinemia and operative incisions there was disruption or failure to heal in 8 cases. The authors then made abdominal incisions in hypoproteinemic animals and administered lyophilic serum after operation. Healing was grossly normal while microscopic examination showed only intercellular edema. The authors submitted a corollary in that lesions of the stomach, duodenum and biliary tract were often characterized in hypoproteinemia.

Hartrell Winfield and Irvin (17) studied 20 cases of abdominal wound disruption occurring in a single year. In all cases the serum protein was below their normal of 6.3 gram per 100 cubic centimeters. The plasma vitamin C determination in all but 1 of the 20 cases were below the author's normal of 0.7 to 3.0 milligrams of ascorbic acids per 100 cubic centimeters of blood plasma.

Numerous investigations on animals and at least 1 man (8-32) indicate that vitamin C is intimately involved in collagen formation.

Ingalls and Warren stressed that patients with peptic ulcer were prone to vitamin C deficiency because ulcer diets exclude many foods containing vitamin C while the alkalis which many were taking tended to destroy the vitamin.

The dosage of vitamin C is a matter of much dispute. Wolfer and Hoebel (12) advise a dosage of 1000 milligrams a day for 9 or 10 days, followed by a dosage of 100 to 500 milligrams a day until the wound has healed. Some workers advise lower dosages. Like the majority of investigators Wolfer emphasizes the importance of determination of vitamin C

excretion in the urine, since this is the only reliable easily available index of the vitamin C requirements of the body

ETIOLOGY

We have mentioned several of the theories presented as to the etiology of evisceration

Hartzell (16, 17) and his associates stress the rôle of protein and vitamin C deficiency. The work of Ingalls and his colleagues with hypoproteinemic dogs has been mentioned. Koster and his co-workers (27, 28) dispute the influence of subnormal plasma protein.

Wolfer and Hoebel (51, 52) ascribe a major rôle to vitamin C starvation.

Glasser, Milbert, and Murphy believe the complication to be due to strains and increased intra-abdominal pressure.

Lahey believes that seratomas and hematomas are the cause of disruption. There is very little evidence to support this theory.

The theory of Freeman has received accord from several authors (5, 6, 46). It was Freeman's concept that imperfect and incomplete closure of the peritoneum resulted in the incarceration of omentum or bowel. With resultant edema and exudate the incarcerated tissues acted as a progressively enlarging wedge, which enabled additional intra-abdominal contents to escape.

Kross and Sims attempted to demonstrate the validity of Freeman's theory in experimental animals. The former succeeded in producing evisceration in 37.5 per cent of 16 rabbits by leaving a portion of the abdominal incision open or by loose sutures of the latter.

Sims stated that injection of a lymph-like substance found in the experimental wounds which included incarcerated omentum provided digestion of the abdominal wall tissues when injected into other animals.

Kraisel, Hinton, and Babcock independently express the belief that some patients are allergic to catgut, but their theories have received considerable criticism.

Meleney and Howes approach the subject from a standpoint of a lag in the normal process of healing, and tissue and suture strength.

Whipple and Elliot stress a combination of some of the conditions given and mention infection as a contributory cause.

Norris believes that improper closure is the chief cause.

Ducuing described thrombophlebitis in 4 of 5 cases.

Weber postulated a decreased pH of tissues causing dissolution of suture material.

No conclusive evidence has been submitted by any author, however.

PATHOLOGY

Nothing of very characteristic nature is known about the morbid anatomy of evisceration. The lack of definite data in regard to the pathological findings is perhaps a proof of the meager knowledge of the condition.

The gross appearance of the disrupted wounds in our series was not described in 4 instances. In 5 cases it was stated that the wounds were grossly infected. In 10 cases definite mention was made of the absence of infection. In 34 cases no definite statement was made. The remaining operative notes are lacking.

In 5 cases closed throughout with black silk it is stated that the sutures had torn through the tissue, although the knots had not been loosened or untied. In 1 case closed with catgut and silk, the figure-of-eight fascial silk sutures had broken.

In 6 cases closed with through-and-through silver wires, the wires broke in 3, in 2 a loop of bowel had extruded between unbroken silver wires, and in the last gross infection with breakdown of the wound necessitated secondary closure.

In 7 cases in which catgut was used the sutures were described as in shreds, disintegrated, or rapidly absorbed.

As has been noted in the literature there was seldom active bleeding from the wound edges. In fact no mention of hemorrhage is found in any of our operative notes. It has been observed by various investigators that the wound edges were "brittle and soft" (3), "dirty and glassy" (26) or like "chronic granulation tissue" (50). The notable absence of bleeding has been used as evidence of some (26, 50) that disruptions occur long before they are recognized and that active bleeding had ceased when the complication has been discovered.

EVisCERATED STRUCTURES

The most common of the intra-abdominal contents presenting in the disrupted wound was the omentum which was noted in 20 (36.3 per cent) cases. Small bowel was noted in 10 cases (18.1 per cent). In 15 additional (27.2 per cent) cases the operative note includes mention of bowel but does not specify whether it was small or large bowel. Among other viscera mentioned as presenting in the disrupted wounds were the transverse colon, stomach, bladder and liver. The only account of the histological picture of the tissues forming the edges of an eviscerated wound in the human being is given by Glasser who stated that section revealed an infiltration with lymphocytes and leucocytes especially in the subcutaneous fat tissue. The fat tissue showed a greatly increased number of fat nuclei with diminution of the fat forming large intercellular spaces.

The signs and symptoms of wound disruption are meager. In many cases the temperature and pulse may show no elevation. Pain is not thought to be a common symptom. Glasser observes that evisceration may be accompanied by signs of shock. Several authors stress the presence of signs of intestinal obstruction with disruption due to incarceration of a loop of bowel in the wound. The patient may volunteer the information that there was a sensation of "something giving way." There may be fullness, boggy, or crepitus beneath the often intact skin. Lahey recommends probing the incision in such cases.

The most common finding in eviscerated wounds is the presence of a serosanguinous discharge which may occur several days after disruption.

In 24 (43.6 per cent) of our series a serous or serosanguinous discharge was noted. Seven (13.4 per cent) cases were characterized by exudate of various types which included bile tinged and purulent drainage. In 24 cases (46.1 per cent) no description of exudate could be found.

The average date of disruption was 7.5 days after the primary operation. This is in accord with the statistics found in the literature in which the most common date of disruption is placed between the 5th and 9th days. The

earliest disruption occurred 16 hours after the primary closure, the latest on the 17th and 19th postoperative days. The incidence of disruption in relation to the postoperative day is given in Table VIII.

TABLE VIII.—INCIDENCE OF DISRUPTION

Day of disruption	No. cases	Total
3		3
4		2
5	3	5
6	9	14
7	3	17
8		3
9	5	20
	3	23
	3	26
1		1
9		1

It was the opinion of several authors (15, 50, 13) that the high incidence of wound disruption between the 5th and 9th days is more apparent than real. It was pointed out that skin sutures are generally removed during this period and that a common early finding in evisceration is the disruption of all layers subjacent to the skin, suggesting that the process had begun some time previously.

SECONDARY CLOSURES

In a preceding paragraph it was stated that there may have been cases of wound disruption in our clinic which may not have been treated surgically. This is improbable although statistics are not available. To the knowledge of the author there were no cases in which patients were treated nonsurgically or by delayed secondary closure.

The treatment of evisceration in this clinic has always been immediate secondary closure with through-and-through silver wire or steel wire sutures. This same procedure was outlined by Reid, Zinniger and Merrell for primary closure of potentially infected wounds. Twenty-six surgeons performed the secondary closures.

In 33 cases, 60 per cent, local anesthesia was employed. In 21 cases, 38.1 per cent, general anesthesia was used. In 1 of these 21 cases to supplement local anesthesia. Intravenous anesthesia was used in 1 case, 1.8 per cent.

Method. The method of secondary closure in 48 cases, 87.4 per cent, consisted of through

and-through steel or silver wires with cutaneous sutures of fine black silk. Variations found within this group include 2 patients in whom drainage was carried out and 4 patients in whom the closure was re-enforced by peritoneal or fascial sutures of catgut or silkworm gut

In 1 case closure was with through-and-through braided silk, and in another with silkworm gut through-and-through sutures. In the latter drainage was carried out

In 1 case a loop of bowel had extruded between the silver wires. After the wires were loosened the bowel was reduced and the wires were again tightened

The operative notes of 4 secondary closures were not available

TREATMENT

There is a general agreement on the broader aspects of the treatment of evisceration. The majority agree that immediate secondary closure is desirable in those cases in which the procedure will be tolerated. Those patients whose condition is critical are treated with adhesive tape strapping with or without packing

All types of anesthesia have been recommended, but the possibility of further evisceration during a difficult induction of general anesthesia is to be considered (18). Through-and-through sutures of silkworm gut (13), silver wire (39), No. 2 chromic catgut, braided silk and dermal sutures have been used in various clinics. Other workers have used layer closures (13) or a layer closure supplemented by through-and-through sutures (3). Some men (13, 46) have advocated enterostomies prior to secondary closure. Pool and Starr and Mason advocated needle aspiration of dilated bowel prior to closure

Colp, Shipley, Meleney and Howes describe fundamentally the same method of modified secondary closure. The wounds are packed with gauze over which through-and-through sutures are placed. As the subsequent steps the sutures are drawn up as the packing is removed, until several days later the granulating surfaces are approximated. In a somewhat similar fashion, Horner placed a rubber dam over the eviscerated bowel and placed fascial

sutures over this tampon. The use of drains is advocated by Bellin and Glasser

Adhesive tape approximation, simple packing, or a combination of the two is employed in patients (14) who are in critical condition and by some for infected wounds. The mortality of patients treated by immediate secondary closure is much less than for those treated with delayed closure. This is explained in part by the generally more critical condition of patients treated by the latter method

MORTALITY, FOLLOW-UP

Only 1 patient in our group suffered recurrence of evisceration. In this case disruption occurred 7 days after through-and-through silver wire secondary closure. Bowel had extruded between the intact silver wires. The latter were removed and tertiary closure by the same method was performed. The patient was dismissed subsequently in good condition. At least 6 cases (26, 16, 21, 33) of recurrence are found in the literature, one of the patients died after evisceration recurred following unsuccessful secondary and tertiary through-and-through closures (23)

The extremely low incidence of recurrence after secondary sutures has been stressed by Cave, Kross, Glasser, Bellin, and Starr and Mason. No satisfactory explanation has been given for this phenomenon. One possibility is suggested by the work of Meleney and Howes who demonstrated that healing is divided into two phases, an exudative and a reparative phase. The initial stage is rapid, but decreases in rapidity at the end of 7 to 10 days. Were evisceration to occur in patients with delayed or impaired healing at the period of maximum weakness, it is conceivable that secondary sutures in the average case might be performed at the approximate onset of the accelerated stage of healing

Boland describes a remarkable case of healing after secondary suture. Nine days after the primary operation the surgeon removed the sutures. The surgeon then went out of town. Evisceration occurred and the wound was secondarily closed with through-and-through sutures by the surgeon's associates. On the following day the surgeon visited the

patient and believing that he had forgotten to remove the sutures, proceeded to do so again. The patient recovered without incident.

There were 22 deaths in our series, a mortality of 40.0 per cent which compares reasonably with the statistics from other clinics. Melaney and Howes 44 per cent Colp 28 per cent Grace 39 per cent White 55 per cent Maes, Boyce and McFetridge, 30 per cent.

The most common causes of death were peritonitis and pneumonia. Among other causes of death were the hepatorenal syndrome subacute bacterial endocarditis, and uremia. One patient returned to the hospital 1 month after secondary closure, suffering with intestinal obstruction and died following an operation for that condition. Of the 32 patients, 58.1 per cent that recovered no follow-up is available in 12 instances. Nine or 43 per cent of the 21 remaining patients developed hernias or defects in the operative scars. Three or 14 per cent of the 21 patients who were followed were readmitted with intestinal obstruction from 2 to 3 years following the secondary closure.

CONCLUSIONS

1 Fifty five cases of laparotomy wound disruptions are reviewed.

2 It is believed that wound disruption results from a combination of factors including postoperative strains, primary or associated debilitating disease hypoproteinemia and vitamin C deficiency.

3 Although the series of cases is too small to make definite conclusions, those patients who survive secondary closure are apparently predisposed to intestinal obstruction and hernia.

NOTE.—We have encountered additional cases of evisceration. Those occurred through drained McBurney incisions with Weir extensions; one of whom died after secondary closure; the other recovered under conservative therapy.

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PYOGENIC COXITIS

II Indications for Surgical Treatment in Residual and Chronic Stages and End-Results of Reconstruction in 53 Patients

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IN a previous paper which reviewed factors bearing on end-results from suppuration within the hip joint, it has been determined that the age of the patient at onset and the extent and severity of accompanying bone infection were the most important influences that were not under control of the surgeon. Similar facts have been pointed out but not thoroughly analyzed by other authors. These factors all determine the amount of bone lost and the frequency of hip joint dislocation when indifferent treatment is applied. Meticulous treatment substitutes controllable beneficial factors which partially counterbalance unfavorable factors and can modify the course of the disease in a favorable direction. Early diagnosis by joint aspiration, relief of joint distention by aspiration or arthrotomy and separation of the articular cartilage surfaces by traction, all serve to prevent, in many cases, the extreme disabling sequelae in this disease. One hundred and six patients among a larger group of 132 patients with 147 involved joints came to our attention with residual deformity or other chronic disorders. Eighty-two reconstructive surgical operations were performed upon 53 of these patients. Others were not treated surgically because the patient or his parents did not wish anything done or because the proper indications were not present. In following the histories of these patients in retrospect, it was seen that the majority of the disabling sequelae might have been prevented by the early and assiduous application of the treatment pre-

viously outlined for the acute and recovery stages.

These principles are poorly understood in many quarters and in the cases reviewed here have been applied indifferently or not at all. The orthopedic surgeon will probably continue to encounter numerous disabilities which are the sequelae of suppurative disease of the hip joint. Our review of this group of cases has been valuable in determining the incidence of certain deformities and complications that commonly result from this disorder, and, in addition, in determining which procedures are likely to yield the best results in reconstructing the deformities observed.

There are few reports in the surgical literature presenting actual experiences in the reconstruction of sufficient numbers of these cases to make an adequate record upon which further work can be based. The current impression is that years should elapse between the subsidence of acute symptoms and the performance of elective operations aimed at correcting deformity. There is no unanimity of opinion as to the most desirable end-result: a movable imperfect hip joint or a painless stable joint secured by osseous ankylosis. There are, of course, situations largely personal and occupational in nature which clearly call for bony union with complete elimination of the hip joint. These will be pointed out in a later section of this paper.

In our previous communication dealing with end-results from suppuration in the hip joint as observed with and without treatment, we found the cases to fall naturally into three groups. There were important differences in the course and outcome from suppuration between these groups which seemed to be conditioned largely by the extent of bone suppuration and by relative proportions of bone and

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TABLE I—RESULTS OF TREATMENT

Condition and operation	Cases	Number of cases having results	Percent of cases having results
Continued purulent drainage Necessitating for all in part of the femoral head			87
Radical excision of the abscess for chronic osteomyelitis		4	34
Hip joint disarticulation			64
Malunion at the hip			100
Subtrochanteric osteotomy at the head of the femur			100
Subtrochanteric osteotomy in the presence of movable hip			100
Transplantation of the greater tro- chanter			100
Unilaterally unstable hips (dislocated or dislocating)			100
Surgical arthrodesis			100
Acetabular shelf operations	7 ¹		
Reconstruction by longitudinal oste- otomy			100
Unilaterally ankylotic hips			
Joint pseudarthrosis operation			100
Femoral arthroplasty			100
Salvage arthroplasty			100
Partial hips			100
Surgical arthrodesis			100
Femoral arthroplasty	Case		
Thighs by length control long bones			100
Femoral shortening			100
Epiphyseal arrest operation (angle femoral bone)			100
Multiple			100
Radical deformities from bilateral sup- purative coxitis			
Unilateral movable			
Bilaterally movable, one side unstable			
One ankylosed in acetabulum with contralateral hip dislocated			
Bilateral stable bony ankylosis			
Total cases			
Unilateral femoral arthroplasty for bilateral ankylosis			
Joint pseudarthrosis operation			

¹ Movable hip, subsequent stiffness.
No treatment was attempted in this group in general, because they were observed before arthroplasty became successfully applied.

cartilage about the hip. The outcome appeared to be independent of the infecting micro-organisms except as conditioned by the factor of extent of involvement. These groups were (1) from 0 to 3 years of age inclusive (2) from 4 to 12 years of age and (3) an

adult group 13 years of age and over. It was seen in the first two groups, especially in the second group which included the bulk of cases that a movable and painless hip often resulted and was a desirable end result even though a variable amount of bone of the femoral neck was lost through suppuration and even though osteoarthritis might supervene three decades later. A stable fused hip especially if superior displacement and dislocation were prevented by traction was the usual outcome in adults and in certain cases in the juvenile and adolescent groups. This outcome appears likewise desirable. Indeed in the older cases if bony union did not occur with elimination of the joint pain was the usual outcome. Surgical treatment is often indicated to eliminate pain. We have found it convenient to retain the classification of cases according to age in considering the indications for and end-results from operative treatment of the residual deformities met with in this group of cases, since there was a lag between the acute stage of the disease and the time when the patients sought advice for residual deformity. There were few cases encountered in the infantile age group in which disability and deformity indicated surgical treatment. Because of the large amount of cartilage in the infantile upper femur a purpuration at this early age is characterized by a benign immediate course and an outcome of an unstable hip. Most of the cases from the infantile group (15 of 18 or 83 per cent) with unilateral involvement did not present themselves for reconstruction until an average of 8 1/2 years after the acute stage. Of the 3 remaining cases 2 were considered in a previous publication describing a hip reconstruction operation suited to these very young children presenting dislocating hips while the third upon whom a shelf operation was performed at the age of 1 year (Case R V Table II) is considered in a later section of this paper.

CONTINUED PURULENT DRAINAGE

Following the subsidence of the acute phase of pyogenic coxitis and its accompanying acute or subacute osteomyelitis, it is the rule that the incision made for drainage closes promptly. If drainage persists from this region or

TABLE II—RESULTS OF SHLF OPERATIONS FOR SUPPURATIVE COXITIS IN JUVENILES

Patient	Age at onset (yrs)	Present age (yrs)	Time (yrs) between acute disease and shlf operation	Shortening (cm.) (without leg equalization procedures)	Time (yrs) between operation and last observation	Result after years
J G*	0 5	15	6 5	6	8	Gait good. Trendelenburg negative. Passive flexion 60°, tendency to external rotation. Disability solely due to leg length inequality.
R. V*	0 5	10	0 5	0	7	Gait good. Walks without a limp. Trendelenburg negative. Passive flexion 90°. Circumduction 10°.
R E	0 5	18	7 0	6**	0	Hip totally stiff from fibrous ankylosis. Gait excellent.
O C	0 5	17	6 0	5	7	Gait fair. Trendelenburg positive. Passive flexion 40°. Hip stable.
J C.	1 0	17	7 0	2	10	Gait good. Slight flexion deformity. Passive flexion 60°. Adduction, abduction and circumduction 10°.
D L P*	2 0	15	10 0	4	6	Stable hip. Trendelenburg negative. 60° passive flexion. Roentgenograms show advanced changes with flattening and sclerosis in femoral head.
A Z*	3 0	23	12 0	9	8	Passive flexion 90°. Abduction-adduction 10°. Gait poor due to inequality in leg length. Patient refused surgical treatment of the latter condition.

*Denotes tibial peg shlf operation

**Shortening decreased to 2 cm. 3 years after distal femoral epiphyseal arrest

from sinuses about the pelvis or in the thigh for more than 4 to 6 weeks, the surgeon should search for the causes of continued drainage, as he should also do before any reconstructive procedure is done. Occasionally patients are encountered who have had unsatisfactory primary treatment and drainage has persisted for years. Roentgenograms and injection of sinus tracts with opaque materials are the procedures which will yield the most valuable information. The common causes of continued drainage in chronic osteomyelitis are well known: sequestered bone, chronic bone abscesses, and epithelialized sinuses.

In connection with pyogenic coxitis, certain special causes of continued drainage are met which are the special modifications of the causes named, epiphysiolysis of a portion or all of the femoral head is common, especially when traction has been neglected or applied in an indifferent fashion in the acute stages. The detached and dead femoral head, or a portion of it, may remain as a cause of continued drainage. A dead and separated head was encountered in 8 patients in our series. The results of removal are usually dramatic, drainage usually ceasing in a few days. In a single case in our list, it appeared that removal of a portion of the sequestered femoral head caused local reactivation of suppuration with contiguous extension into the supra-acetabular zone and into the femoral neck. This occurred in a patient who appeared to

have little general resistance to suppuration and who later died of local extension and generalized metastatic pyemic abscess. If epiphysiolysis occurs in a suppurative joint which has not had to be drained and about which there are no sinuses established, or if aseptic necrosis of the capital epiphysis occurs without its detachment, the dead segment may be allowed to remain for a few months, to see if it will be transformed and incorporated into the pelvofemoral block of bone which results. The cartilage over the femoral head rapidly disappears from the necrotic femoral head. It appeared that we were successful in 1 case (Fig. 1) in maintaining motion in a hip and in securing union between a separated femoral head and the metaphysis. This was a special instance in which the suppuration was of low grade and in which an incision made for drainage had been healed for several weeks. The methods employed in securing this result would be contraindicated except when the suppuration is of low grade or definitely subsiding.

Extensive osteomyelitis in the pubis, ischium, or ilium is a frequent cause of continued drainage. Since the clinical course from osteomyelitis of the bones of the pelvis is different from that in the long bones, adequate involucrum formation being a rarity and the indications and methods for operation not as well understood as in the case of the long bones, some of the facts concerning pelvic

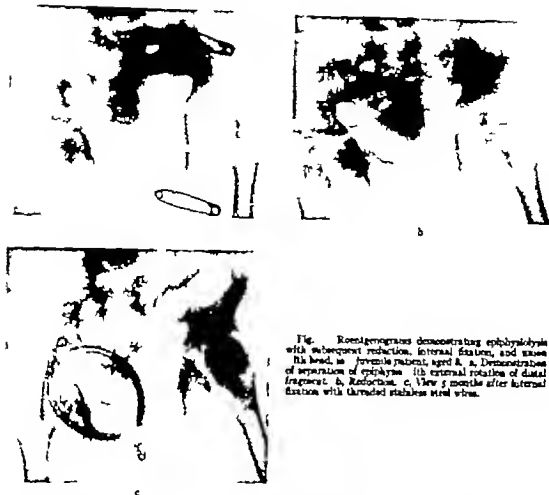


Fig. Roentgenograms demonstrating epiphyseolysis with subsequent reduction, internal fixation, and union. This is a juvenile patient, aged 8. a, Demonstration of separation of epiphyses with external rotation of distal fragment. b, Reduction. c, View 5 months after internal fixation with threaded stainless steel wires.

osteomyelitis will be summarized in this place. This subject has been dealt with in recent years in the writings of Badgley, Young, Milch, and Kulowski. Pelvic, trunk, and thigh abscesses are produced especially from osteomyelitis of the ilium which is the bone most frequently involved. Osseous foci above the iliopectineal line give rise to either internal iliac abscesses which often burrow into the thigh, or to multiple draining sinuses about and above the trochanters and sacroiliac joints depending upon whether the bone foci discharge internally or to the exterior. Pelvic abscesses of various types may develop. Roentgenograms in this chronic stage reveal either sclerous or a segment of the ilium or the

especial mottled appearance which signifies the presence of multiple medullary abscesses and the presence of numerous small sequestra, a situation that is best treated by partial or complete excision of the ilium. The tremendous thickening of this bone and the extent and distribution of abscesses and multiple sequestra from the internal and external tables of the pelvic bones cannot be appreciated except by operative visualization of such lesions. Roentgenograms seldom demonstrate these changes clearly.

Excision of the major portion of the ilium was undertaken 9 times in our cases. Excision of a longitudinal portion of the ischium was done once. The result from the latter was ex-

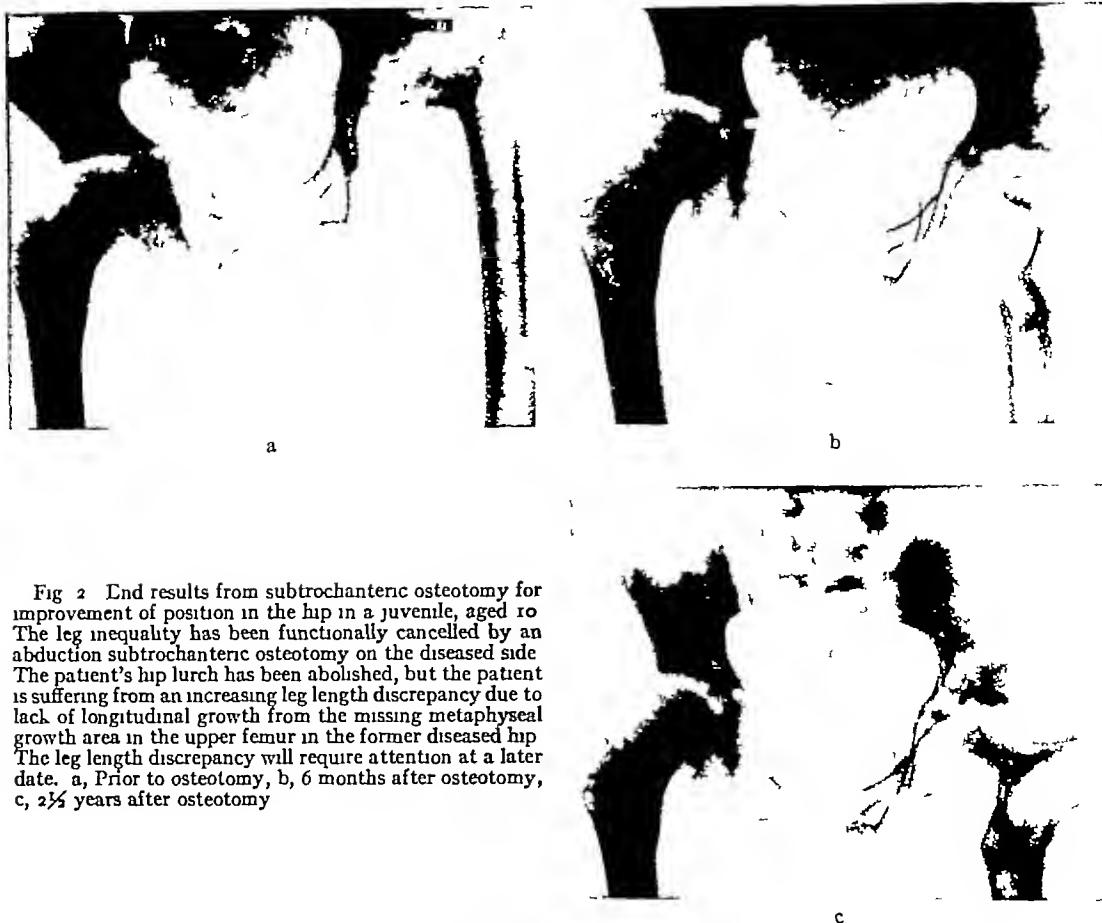


Fig 2 End results from subtrochanteric osteotomy for improvement of position in the hip in a juvenile, aged 10. The leg inequality has been functionally cancelled by an abduction subtrochanteric osteotomy on the diseased side. The patient's hip lurch has been abolished, but the patient is suffering from an increasing leg length discrepancy due to lack of longitudinal growth from the missing metaphyseal growth area in the upper femur in the former diseased hip. The leg length discrepancy will require attention at a later date. a, Prior to osteotomy, b, 6 months after osteotomy, c, 2½ years after osteotomy

cellent (criterion—the elimination of drainage), as was the case in chronic osteomyelitis of the ilium in 80 per cent of cases. Continued drainage was the result in 1 case, and the opportunity was not afforded to investigate the cause further. It is possible, in view of the generally excellent results in eradicating drainage by radical iliotomy, that a better outcome might have followed further treatment. Badgley reported that in 17 of his 20 cases (85 per cent) patients were cured (drainage eliminated).

Disarticulation of the hip joint should receive more consideration in the treatment of persistent suppuration of the hip joint in adults in the presence of osteomyelitis in the upper half of the femur. This is particularly true in the instance of acute spread to this zone

by direct extension or by the blood stream in adults, since they form involucrum poorly or not at all and this procedure is the only means of eradicating a chronic suppurative focus which may later threaten the life of the patient. This operation was done in 3 of our cases (Table I). A fatality occurred in 1 patient several months after the operation since spreading gangrene occurred in the wound, and metastatic suppurative foci developed elsewhere. When the indication is clear, disarticulation should be carried out at once, rather than as a last-minute attempt to save the patient's life.

MALPOSITION AT THE HIP

Attempts to establish the correct relation between the pelvis and the upper femur or the

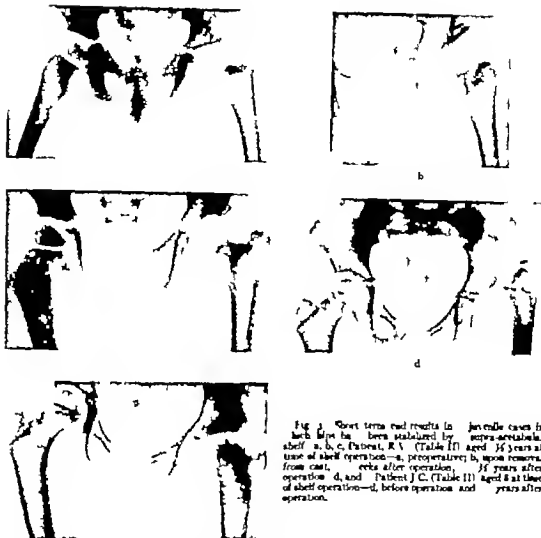


Fig. 3. Short term end results in juvenile coxa vara in both hips has been stabilized by supra-acetabular shelf. a, b, c, Patient, R.V. (Table II) aged 16 years at time of shelf operation—a, preoperative; b, upon removal from cast, 16 years after operation; c, 16 years after operation. d, and e, Patient J.C. (Table II) aged 8 at time of shelf operation—d, before operation and e, 16 years after operation.

remnants of the femoral stump should receive first attention during the stages of acute suppuration. The natural and comfortable attitude of flexion and adduction should be combated in the acute stages by traction or casts. The question of pathological dislocation in one or both hips in suppurative hip joint disease will be dealt with in the later section in which the problem of bilateral hip joint suppuration is discussed.

Poor position at the hip is usually associated with an ankylosed joint which was through

poor initial treatment allowed to stiffen in malposition. In the growing child or in those allowed to walk upon the leg without support when the new bone bridging the joint is not firm, an acquired malposition develops usually in flexion and adduction. Ankylosis in gross abduction is occasionally the result of disregard of position during the acute stages. Up to 30 degrees of abduction if no flexion is present may be desirable especially when the involved femur is slightly shorter or has lost some bone at the hip through dislocation or

suppuration Abduction of that degree is often the partial or complete aim of subtrochanteric osteotomy for positional correction, since every 30 degrees of abduction is equal functionally to an increase of 1 inch of leg length

In the absence of a movable hip, only roentgen study of the pelvis can help in the decision to osteotomize the movable femur for positional correction, or to perform a surgical arthrodesis The special indications in this situation for surgical arthrodesis will be discussed in a later section dealing with the end-results from this procedure In general, pain and an unstable hip are the usual indications for it The indications for subtrochanteric osteotomy for positional correction when a movable hip is encountered in the residual deformity from suppurative hip joint arthritis are (1) to increase hip joint stability when incipient dislocation is present—this is usually associated with a short or missing femoral neck remnant (2) to obtain minor degrees of functional leg length increase (up to one inch)

The presence of hip joint stability or the probable result of hip joint stability is a prerequisite to the performance of a subtrochanteric osteotomy in the presence of a movable hip (Figure 2 is an illustrative end-result) It should be stated that osteotomy in the subtrochanteric region to improve position is the operation that is most frequently indicated to remedy the deformities resulting from the disease At the same time the results are satisfactory (100 per cent in our series of 15 operations) If it can be postponed in the growing child until the age of 12 or 14 years, the likelihood of having to repeat the osteotomy later for recurrence of deformity, which is a common result in younger children (up to 10 years), can be avoided

Listed with these operations in Table I are 3 cases in which "transplantation of the greater trochanter" was performed When the mechanics of muscle pull in the presence of an incipient or dislocated hip are considered, the downward shift of the greater trochanter is the mechanical equivalent of performing an abduction osteotomy in the presence of a movable hip The author is of the opinion (based upon the results in these 3

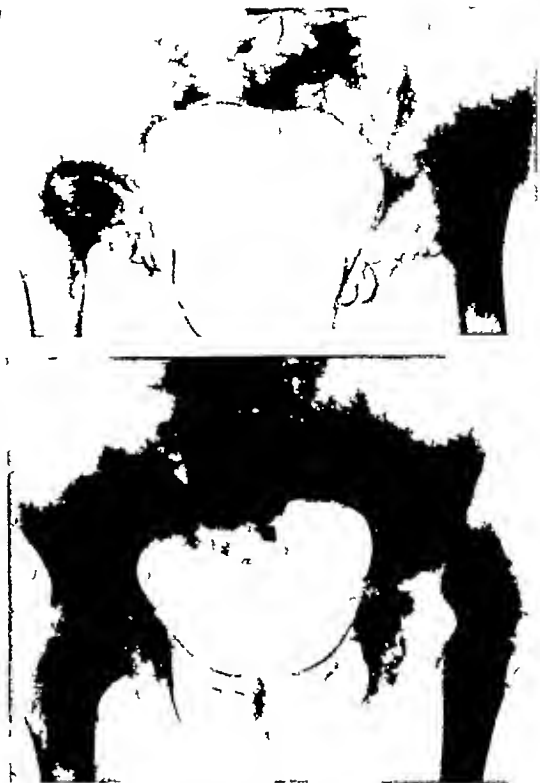


Fig 4 Illustration of the extensive deformities in 2 cases of bilateral suppurative arthritis of the hip

cases and in other cases in which the operation was performed following the shelf operation for congenital dislocation of the hip) that gait is not improved following it The operation of trochanteric shift makes less the likelihood of osseous displacement of the upper femoral fragment out of the acetabulum For the residual deformity associated with a short femoral neck remnant in this condition, it is our opinion that simple abduction osteotomy in the presence of a movable hip, is the operation of choice, being simple and easier to perform and more certain in outcome This is likewise the opinion of Moore, reporting upon the same group of juvenile patients with residual movable hips following suppurative hip joint disease It should also be borne in mind that many of these patients will probably develop painful hips in later years and require a procedure for the elimination of pain The period of follow-up on our juvenile pa-

tients was not sufficiently long to carry them into middle age in order to determine this point statistically. However 5 patients in the adult group were treated by surgical arthrodesis for painful hips, all cases of osteoarthritis secondary to proved suppurative arthritis (see later section on painful hips).

UNILATERAL HIP JOINT INSTABILITY

Complete instability of the hip is the result of preservation of motion following purulent destruction or sequestration of the head and subsequent loss of the femoral neck by "absorption" which in many cases is the result of pressure and necrosis. The possessor of such a unilateral unstable hip has an unsightly "hip lurch" produced by pelvic sag when the weight is supported upon the unstable lower extremity. The result to be achieved by treatment is hip stability. In the adult, the only means of obtaining this result is surgical arthrodesis of the hip which is performed following placement of the dislocated hip at the level of the acetabulum to restore leg length lost by the dislocation. This operation was performed under this indication in this age group three times in our cases all with marked improvement in gait.

In the juvenile group the shelf operation is the procedure of choice. It can be performed 6 months after the cessation of drainage provided there are no residual bone markings of associated osteomyelitis, in which case the operation had best be postponed several years until these are eliminated or become suited for operative intervention (see section on operation in ankylosed hips). Table II gives the results from the shelf operation as performed on 7 patients in this age group. The results were good (stable hip and "good" gait) in 5 of the 7 cases (71.3 per cent). In a 6th case the outcome was excellent but the object of the operation failed as osseous ankylosis developed. The end results justify the employment of the operation to secure a movable and stable hip in juveniles with unilaterally unstable hips. The number that will develop pain at a later date is unknown.

In a previous report we have presented the result in an instance of longitudinal osteotomy for reconstruction to remedy the dislocating

hip in an infant. L'Episcopo has presented the results from a similar operation in children in the juvenile group. It should be noted in Table II (Case R V) that the shelf operation was performed on a child 1 year of age 6 months after suppuration occurred with a good 7 year end result (Fig. 3). The patient was no longer available for follow up after this time. Discrepancies in leg length that become apparent in later years often mar an otherwise excellent result at the hip. This again brings out the necessity to follow these juvenile patients to maturity and to carry out an appropriate procedure for leg equalization.

UNILATERALLY ANKYLOSED HIP

One of the best end results that may be secured from suppuration within the hip joint is a stable hip obtained by osseous ankylosis, especially if there has been no shortening due to loss of bone at the hip. However the orthopedic surgeon is continually being confronted with young adults formerly the victims of suppurative hip joint disease who wish to obtain a movable hip. If there is much evidence of bone markings in the roentgenogram due to small abscesses or sequestra in or near the line of proposed osteotomy to mobilize the femoral head or if there has originally been extensive osteomyelitis contiguous to the hip joint no attempt should be made to secure a movable hip because of the danger of reacting the former bone infection. Davis has published an important study dealing with the criteria to be observed in preventing recurrence of infection after elective operations in cases of healed suppuration in bones and joints. He found that "it is possible to anticipate the recurrence of infections from the roentgen appearance." There were no recurrences of infection in operations on gonococcal joints, even if the reconstructive operation be executed within 6 months of the subsidence of the disease. The period of quiescence had little to do with conditioning recurrences. The recurrence rate was 13 per cent in mobilizing operations upon former septic joints, which was quite similar to the recurrence rate of 10 per cent found by Hallock. The rate was low red t
operation was done in

healthy bone but "near" the former site of suppuration. This "recurrence rate" is likely to be lowered more with the local and systemic use of the sulfonamides.

Most of the operations to be reported in this section were done before the current period of interest in foreign body cup arthroplasties. The end-results obtained must then be considered as representative of procedures that are not at present the operations of election. The outcome from the Jones pseudoarthrosis operation was re-ankylosis in all 3 hips. Judged by modern standards, this procedure is a makeshift operation. Fascial arthroplasty was performed on 6 patients, all adults. Only 1 (20 per cent) presented a satisfactory end-result (adequate motion, no pain and a stable hip). The cause of the unsatisfactory end-results was aseptic necrosis and absorption of the reconstructed femoral head in 3 cases and reankylosis in 2 cases. We performed a vitalium cup arthroplasty in 1 instance with a very satisfactory end-result.

There are no statistics in the literature on hip arthroplasty as applied to the residual form of suppurative arthritis of the hip, except those from Steindler's clinic, reported by Fuks in which "good" and "fair" results were obtained in 77 per cent of 9 cases. These were not analyzed in detail. Steindler presents statistics summarized from the literature showing that "good" and "fair" results from hip joint arthroplasty aggregate 64 per cent. Hallock and others have commented upon the frequency with which re-ankylosis occurs in attempts at arthroplasty upon patients who formerly had suppurative hip joint disease.

The advent of the foreign body cup, which has simplified the technique of hip joint arthroplasty, has again reopened this field. The use of vitalium cups, which are opaque to roentgenograms, does not make it possible to follow osseous changes in the remodeled femoral head. The frequency of collapse of the neck fragment following arthroplasty for the residual from suppurative arthritis of the hip makes it desirable that an attempt be made to follow any changes that may occur following cup arthroplasty. The use of non-metallic cups of methacrylate plastic makes such observations possible. As yet, no end-

results in sufficient numbers following vitalium cup arthroplasty for this condition have accumulated.

The problem of attempting to secure a satisfactory result from arthroplasty of the hip in deformities from suppurative arthritis should be approached in each case upon an individual basis. In general, if the patient has a stable hip, ankylosed in good position, he should be discouraged from attempting to secure motion in the hip, as the outcome from arthroplasty is distinctly a gamble in a single case. This fact, the technical aspects of the operation, and the necessity for vigorous postoperative exercise, should be understood by the patient before he submits to the operation. The specific conditions that should be met before performing hip arthroplasty for this disorder are:

- 1 The patient should enthusiastically desire the operation and be willing to sacrifice enough energy and time to comply with the vigorous postoperative schedule.

- 2 The patient should always be under 50 years of age and in good general health.

- 3 No draining sinuses can be present.

- 4 Roentgenograms must demonstrate the absence of osteomyelitic changes at the former hip joint site and in neighboring bones. Magnified views should be carefully examined for small bone abscesses and sequestra.

- 5 The patient's occupation should be a "light" or sedentary one. If he is a laborer or employed in an occupation in which he must stand or walk many hours a day, an ankylosed hip in good position is preferable.

- 6 Gross distortion of bone in the pelvis and upper femur must be absent and there must be no fibrosis or extensive atrophy of the muscles about the pelvis.

A patient with bilaterally ankylosed hips is considered by some to be especially desirable for arthroplasty of the hip. This condition, as well as original involvement of both hips, followed by ankylosis of one, is neither an indication nor a contraindication for the operation, as individual evaluation upon the basis of the conditions enumerated above is of greater importance.

PAINFUL HIPs

When motion is preserved in the hip joint, the site of alterations produced by previous

disease, it is likely that pain with or without osteoarthritis will develop in later years. This condition was observed in 5 adults among our cases. All were treated by operative fusion of the joint with satisfactory results in each case (painless and stable hip). The disadvantage to the patient is the usual one of a stiff hip i.e., difficulty in sitting and extra strain in the low back area. These disadvantages must be balanced against the patient's current disability from hip pain. In all of our 5 cases gait was improved because of relief from pain. No arthroplastic procedures were performed upon the indication of pain. The relief from pain now known to be afforded by foreign body cup arthroplasty would indicate the use of these newer methods before arthrodesis is resorted to.

UNEQUAL LEG LENGTH

Functional inequality of the lower limbs must be constantly evaluated in these patients. These factors are at work superior displacement in the unstable hip, loss of bone due to suppuration and shortening due to malposition in flexion and adduction. Roentgenograms of the pelvis and physical findings are both essential in evaluating these 3 factors. The first and last can each be dealt with by appropriate operative means. Direct measures designed to equalize leg length are sometimes indicated. Fourteen patients had surgical operations (leg shortening, leg lengthening or epiphyseodesis for arrestment of longitudinal growth) performed upon them (Table I). Surgical leg equalizations were recommended but refused by the patients in 12 additional cases. Of these three procedures, it would appear from our results that diaphysectomy for leg shortening was the operation that yielded the desired end result consistently. However, it should be pointed out that some

of the epiphyseal arrest operations were performed upon older adolescents that are now known to have been operated upon too late to expect sufficient growth cancellation. The knowledge of this factor should enable better selection of cases for the epiphyseal arrest operation. Leg shortening, on the other hand is an exact procedure the results of which are obtained quickly and with certainty. Space cannot be given here to a detailed discussion

of the indications and results from these 3 surgical procedures. The reader is referred to original descriptions and reviews of the subject.

RECONSTRUCTION OF DEFORMITIES FROM BILATERAL SUPPURATIVE ARTHRITIS OF THE HIP

Similar to the state following unilateral suppuration in the hip, only half of our cases falling into this division presented bilateral osseous ankylosis of the hips (8 of 15, or 53.3 per cent). Ambulation in these latter cases, which is accomplished by alternately pivoting on the lower extremities, had resulted in a fairly good gait, considering the disability. Among the 8 ankylosed cases, vitalium cup arthroplasty was carried out bilaterally in 2 cases with good results. The adolescent age of these patients undoubtedly favored the result since such a good function is seldom obtained in adults with bilateral ankylosed hips from any cause.

Of the 7 other cases, only 2 were satisfactory presenting stable and movable hips that did not need consideration for reconstruction (Fig. 4). It is highly probable that these 2 cases will develop osteoarthritis in succeeding years because of the slight to moderate deformity in the femoral heads. The 5 remaining cases presented appalling deformities (Fig. 4) grouped as follows: bilaterally movable hips with unilateral "instability of gait" but without dislocation, 2 cases; 1 hip ankylosed in acetabulum by bone associated with dislocation of the other hip, 3 cases. No operative procedure was attempted in the 2 cases with movable hips with gait instability in one hip.

As was pointed out for the acute stage in the previous paper, it is desirable to reduce the dislocation when present. Badgley's experience was that reduction in 17 cases when dislocation occurred resulted in 8 cases of ankylosis and a "satisfactory" result in 8 others (50 per cent or more of motion). Approximately the same percentage of ankylosis (60 per cent) occurred after reduction of dislocation in our acute cases presenting this complication. Bilateral dislocations, as a complication of the acute stage, do not alter the desirability of reduction at this time since

there is better than an even chance that one hip will remain in place and will have greater than half a normal range of motion. It is, of course, highly probable that later, degenerative changes leading to osteoarthritis in one or both hips will follow.

ANALYSIS OF OBSERVATIONS

No dogmatic statement can be laid down as to the optimum age at which reconstructive procedures should begin. This, of course, depends directly upon the patient's age at the onset of the acute phase and the rapidity and effectiveness of control of the initial suppuration. In the case of long continued discharge from deep sinuses, the measures aimed at closing these, largely a search for, and correction of, elimination of mechanical causes (sequestra, epithelialized sinuses and chronic osseous abscesses), are quite effective. The results obtained in this series are better than the average seen in this type of patient in all age groups, since the majority of our patients were adolescents and young adults many of whom had had the onset of the acute disease several years earlier. In a few months after subsidence of the acute phase, measures can be undertaken to eliminate discharge from draining sinuses that promise not to close otherwise. After elimination of mechanical causes, as discussed in the first section of this paper, the daily instillation of a stable 20 per cent suspension of the microcrystals of sulfathiazole hastens the closure in cases in which the staphylococcus is the infecting microorganism. Sulfanilamide powder or solution can be similarly used.

Reference to Table I shows that the procedures used in reconstruction of the single hip damaged by suppuration are highly successful in juveniles. The difficult problems dealing with plastic procedures about such a damaged hip yield good results in a high percentage of cases, if performed during the last half of the first decade of life or during the early part of the following years. In adolescents or young adults, these plastic operations, including the acetabular shelf, do not give satisfactory results largely because of subsequent pain. Indeed, it must be kept in mind that a certain number of these operations performed upon

juveniles will, after the passage of many years, develop pain, and will then have to have treatment directed toward that symptom. However, the fact of the fair incidence of satisfactory results that are relatively permanent warrants continuation of these reconstructive procedures.

Malposition at the fused hip should not receive surgical attention until after the approximate age of 12 to 13 years, unless the malposition is grossly exaggerated, when it may be necessary to correct it earlier by osteotomy. However, it should be remembered that osteotomy at earlier ages is seldom a permanent correction as a portion or all of the deformity will recur and need a later correction. Osteotomy in the presence of a movable hip is not subject to the same rigid age limitations, as this is usually done to increase hip stability. In the very young patient (under 3 years) special longitudinal osteotomy can be done to create an articular surface for the upper femur when the damage to the acetabulum is minimal. All these types of osteotomies lead to a uniformly good result, especially when surgical correction is performed for any associated leg length inequalities.

In general, surgical stabilization of slightly movable hips and positional correction in those already naturally ankylosed by the acute disease yield better permanent results in terms of painless extremities serviceable in weight-bearing than arthroplastic attempts to secure a movable hip. Indeed, a number of hip joint arthroplastic procedures were unsatisfactory when performed upon hips ankylosed as the result of suppurative joint disease. Subsequent collapse of the newly formed femoral head was the chief cause of failure. This complication arose because of the altered vascularity produced by sclerosis of this portion of the bone. Since this is a defect in the bone upon which the surgeon is called on to operate, this factor is not under his control and at the same time makes it improbable that the newer types of foreign body cup arthroplasties will yield radically different results when applied to unselected cases.

For the equalization of leg length, the bone shortening operations yielded uniformly satis-

factory results in our hands. The epiphyseal arrest operations that were performed were largely done upon adolescent girls and were performed too late since at that time it was not fully appreciated that longitudinal growth of the long bones in girls often ceases as early as 11 to 13 years. Proper selection of cases would undoubtedly lead to better results in the application of this operation. However since the leg shortening operation is an exact procedure the correction being obtained at once it appears to be the operation of election to be performed for this purpose. It can be applied in the growing child in the latter half of the growth period provided prolonged previous observation has established the fact that the leg length discrepancy is not a progressive one.

The least satisfactory end results were seen in patients presenting bilateral deformities from acute involvement of both hips. Since these patients were seen before the modern era of arthroplasty little treatment was attempted in them.

SUMMARY AND CONCLUSIONS

A review of the end results from surgical reconstruction of the residual deformities encountered in 53 patients who previously had suffered from acute suppuration within the hip joint is presented.

Measures aiming at eliminating chronically discharging sinuses and those carried out upon the single damaged hip yielded as an average satisfactory results in more than 80 per cent of cases.

Positional correction of the single ankylosed hip subsequent ankylosis of the painful hip and certain plastic operations that can be executed upon juveniles are more satisfactory

than the arthroplastic procedures that aim to confer motion on an already ankylosed hip that has resulted from bone suppuration.

Patients that have bilaterally damaged hips the sequelae of the condition are an appalling group of cases that do not radically change their status following the surgical procedures that can be performed upon them. Occasionally arthrodesis of a single unstable and dislocated hip may be indicated in this group of patients. This group of patients needs further intensive study.

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HEMORRHAGIC SHOCK

The Relative Effect of Saline, Washed Red Cells, and Heparinized Plasma in Dogs

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THESE experiments were undertaken in view of the recent interest regarding "hemorrhagic shock" and related war problems. An attempt was made to devise a method which could be easily duplicated for the production of this condition. We shall report the effect of saline, plasma, and washed red cells on dogs which were in a state of posthemorrhagic circulatory collapse, commonly referred to as shock. Investigators have used many methods for the production of shock and have tested many different solutions for its treatment. It is well known that saline has a temporary sustaining effect on humans and animals in shock. In both military and civilian practice, whole blood or plasma has been accepted as the treatment of choice in shock. Plasma is generally used because of its ease of preparation, storage, transportation, and administration without fear of serious untoward reactions. Washed red cells have previously been considered a rather poor blood substitute by other workers in spite of the fact that the majority of the effects of hemorrhagic shock can be explained on the basis of anoxia. The literature in this field has become quite voluminous, and only a few pertinent reports are mentioned.

Rossini (1925) stated that washed red cells exerted about the same resuscitating effect as saline in the treatment of acute hemorrhagic shock. Hoitink (1935), using clinical evidence for determining a state of shock, claimed that normal saline was as effective as any of his test solutions, which included simple and complex crystalloid solutions. Magladery and associates (1940) believed that serum and plasma were effective in posthemorrhagic shock in dogs, and stated that 40 per cent or more of

the original blood volume removed must be restored. He also stated that red cells are quite effective but that the red cell volume is more important than the oxygen carrying power. Buttle and associates (1940) found in cats that the red cells suspended in saline were less effective than plasma, serum, hemoglobin Ringer's, or gum saline solutions. Muirhead and associates (1942) showed that plasma administration caused hemodilution and also stated that complicating factors were introduced by the use of citrate as an anticoagulant and by general anesthetic agents. The recent work of Ivy and coworkers (1943), on dogs, demonstrated that plasma was an effective blood substitute, but he did not use red cells in his series. Ivy's work also serves to show that it is important to administer the replacement solution rapidly and as soon as possible following the bleeding. This was also pointed out by Magladery.

When the term "shock" is used today it means different things to different groups of workers, and the term should always be defined as clearly as possible. The important thing is that each investigator define what he means by the term "shock" or "hemorrhagic shock" in the experiments under consideration. There is some question as to the advisability of using the term "acute hemorrhagic shock," for Wiggers and associates (9, 10, 11, 1942) would reserve this term for an irreversible condition in which resuscitation of the animal's own blood brings about only temporary relief. The animals subsequently died. We see no reason for the reservation of the term "shock" for this condition. Elbert and associates (1942), using similar technique, were unable to duplicate this irreversibility. They kept dogs at a low blood pressure for 12 hours with subsequent recovery of all animals.

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In the final analysis the efficacy of a blood substitute depends on its ability to maintain a satisfactory circulatory state. Such a test solution may be considered adequate if animals receiving it survive without deleterious effects whereas, untreated they succumb.

METHODS AND MATERIALS

All dogs used in these studies were healthy, male and female animals. They were observed for at least 2 weeks before being used and were fed the standard kennel diet of hospital scraps reinforced with Purina dog chow. Most of the animals which survived were used a second time after a period of 3 to 6 weeks to permit blood constituents to return to normal.

Precisely the same technique was used in all animals. The only anesthetic used was procaine hydrochloride 1 per cent about 5 cubic centimeters being injected into the skin and subcutaneous tissues over the femoral triangle. The femoral artery and vein were then cannulated with appropriately sized glass cannulas. Two drip bottles connected with a 1/2 tube were hung about 2 feet above the dog and were attached to the cannula in the femoral vein by a rubber tube. One bottle contained 0.9 per cent saline solution and was used for a slow drip to keep the cannula open about 3 to 5 cubic centimeters being administered in this way during the experiment. The perfusion and transfusion fluids were given rapidly from the second bottle with the aid of positive pressure.

When the primary bleeding from the femoral artery had decreased to a slow drip the collecting flasks were changed and the dog was immediately perfused with 25 cubic centimeters per kilogram body weight of 0.9 per cent saline. This caused an increase in blood flow from the femoral artery for a short period (Table heading "Volume removed after perfusion") which then subsided to a slow drip. At this point the bleeding was stopped and the artery was ligated with silk. The dogs were then in profound shock as evidenced by extensor rigidity, loss of sphincter control, air hunger and in some cases apnea. The volume of the primary bleeding before the perfusion was immediately replaced by the blood substitute and the vein was ligated. A small amount of

5 per cent sodium salithiazole ointment was placed in the wound and the incision was closed with silk. The operating time was 30 to 40 minutes, the bleeding time 2 to 3 minutes, the perfusion time 1 to 2 minutes, the post perfusion bleeding time 4 to 5 minutes and the transfusion time 1 to 2 minutes.

The primary bleeding not followed by perfusion produced shock in about one half of the dogs, but none of them died. Therefore, we added the perfusion procedure. An empirical figure of 25 cubic centimeters of 0.9 per cent saline per kilogram body weight was reached, after finding that when 25 cubic centimeters saline per kilogram was used, immediate death followed whereas with 20 cubic centimeters saline per kilogram death was not produced in any of the animals.

The blood was collected with sterile flasks and rubber tubes. The operating instruments were sterile, the operators and the rest of the equipment clean. When the red cells were to be used 1 cubic centimeter of saturated sodium citrate per 100 cubic centimeters of blood was used as an anticoagulant. When the plasma was saved heparin was used 1 milligram for every 2 cubic centimeters of whole blood. The cells and plasma were separated by centrifuging at 2,000 revolutions per minute for 30 minutes. The cells were then suspended in an equal volume of 0.9 per cent saline, re-centrifuged at 2,000 revolutions per minute for 30 minutes, and again suspended in 0.9 per cent saline. This suspension of red cells was used for transfusion. The whole blood was stored in a refrigerator at 4 degrees C and the cells were washed and suspended immediately before the experiment. When plasma was used it was separated from the red cells immediately after the bleeding and stored overnight in a refrigerator at 4 degrees C. It was filtered through gauze once immediately before being used. The dogs were given access to water and food immediately following the operation and during the postoperative period. Every dog that died was examined postmortem usually within 1 hour after death, but 3 or 4 animals died during the night and no examination was carried out until the following morning.

TABLE I—SALINE TRANSFUSION

Dog No	Wt	Vol of blood removed	Amt. of saline perfused	Vol re-moved after perfusion	Total protein removed		Preoperative sample		3 hour sample		6 hour sample		24 hour sample		Observations
					gm	gm / kgm	P P	Hemat	P P	Hemat	P.P	Hemat	P.P	Hemat.	
1	6.4	290	150	250	22.8	3.58	5.50	35.4							Dead—5½ hrs
2	9.8	440	225	260	29.5	3.02	5.85	38.2							Dead—5 hrs
3	10.5	530	240	310	30.7	3.70	6.40	33.8	3.32	12.0	3.84	11.7			Dead—18 hrs
4	10.3	450	240	250	30.9	3.00	5.84	49.6							Dead—40 min
5	7.6	400	175	200	5.5	3.35	5.20	33.7	3.30	16.8	3.12	16.0	4.05	13.0	Survived
6	7.7	500	177	165	33.4	4.30	6.45	33.0							Dead—½ hrs
7	9.8	455	225	300	30.0	3.06	5.69	43.7	2.91	19.0	3.03	18.6	4.44	13.4	Survived
8	11.7	580	270	370	46.7	4.00	6.72	41.7	3.45	16.0					Dead—6 hrs
9	16.8	1050	386	375	83.6	4.99	7.10	36.6	3.49	13.4					Dead—3 hrs
10	15.2	1000	350	380	75.1	4.90	6.60	31.6	2.70	12.4					Dead—2 hrs
11	12.0	575	276	255	46.3	3.90	6.60	46.0	3.90	21.2	4.2	18.8			Dead—9 hrs
12	9.1	525	210	300	37.1	4.10	5.95	39.4	2.76	18.0	3.48	20.6			Dead—6 hrs
13	9.4	650	216	245	45.9	4.80	6.20	40.0	3.30	15.9	3.80	18.0	4.80	15.9	Survived
14	10.4	555	240	200	44.3	4.30	6.99	34.0	4.03	16.4					Dead—5½ hrs
15	5.9	365	136	155	32.5	5.50	7.70	28.4	3.68	10.8					Dead—3 hrs
Aver	10.2	558	234	268	41.5	4.03	6.32	37.8	3.35	15.6	3.58	17.3	4.45	14.1	12 died 15 survived

The total plasma protein removed was measured by determination of the nitrogen in the primary blood removed plus the nitrogen in the postperfusion bleeding. Samples of blood were drawn by jugular puncture at 3, 6, and 24 hours, after operation. In a few instances the final sample was obtained by intracardiac puncture immediately following death. The 0.9 per cent saline was prepared from chemically pure sodium chloride and singly distilled water. It was neither filtered nor autoclaved, nor was it tested or treated for pyrogens. No visible toxic reaction to any of the infused substances was noted. Hematocrit determinations were made in 15 cubic centimeters graduated hematocrit tubes, centrifuged for 30 minutes at 2,000 revolutions per minute. Nitrogen determinations were run on the plasma. The total nitrogen determinations were made by the macro-Kjeldahl method.

EXPERIMENTAL RESULTS

The results of these experiments are summarized in Tables I, II, and III. The washed red cell series was not as long as the others because of the uniform recovery results obtained.

Table I summarizes the results on 15 dogs in which *saline* was given to replace the vol-

ume of blood removed before perfusion. This primary bleeding averaged about 5 per cent of the animals' weight or over 50 per cent of the animals' blood volume (4, 8). The blood proteins were reduced from a preoperative average of 6.30 grams per cent to 3.35 grams per cent, 3 hours after operation, while the hematocrits fell from an average of 37.8 per cent to 15.6 per cent over the same period. The 3 dogs that survived for 24 hours had slightly increased their plasma proteins, but their hematocrits were not raised. In the 12 fatal experiments, the average postoperative life of the dogs was 5.5 hours. Very little urine was passed and the dogs, though making an excellent recovery initially, went rapidly downhill and died.

In Table II are the results from the *washed red cell series*. The bleeding in these animals was just as severe as in the saline replacement series, but as can be seen the results were totally different. Recovery on the operating table was most rapid and complete with this series, and the animals did not lose ground afterward. They drank well and ate food when offered, and in general seemed little the worse for the bleeding. The hematocrits were slightly lower after 24 hours than the preop-

TABLE II—WASHED RED CELL TRANSFUSION

Dog No.	W.	Vol. of blood removed	Amnt. of saline perfused	Vol. re-normalized perfused	Total proteins removed	Preoperative samples		3 hour sample		8 hour sample		24 hour sample		Survived
		gms.	c.c.	c.	gms.	P.P.	Hemat.	P.P.	Hemat.	P.P.	Hemat.	P.P.	Hemat.	
26	5	23	5	35	21	8.8	44	26	5.2	77	29	23	36	All animals survived
	7	30	170	5	20		40	23	40	80	26.6	26	26	
25	7	30	130	20	3.4	2.30	72	5	23	20	47			
26	10.4	200	245	230	45.7	20	48	8.20	8	40	27	25	34	
20	17	200	223	200	25	20	8.20	45	44.8	26	43	43		
21		200	19	200		80	24	44	3	80	22.2	60	26.8	
	8	47	200	200	22.3		2.72	23	27	26	30	8	24	
23	8	200	205	73	25	20	5.42	5.2	7	23	2.10	23.2	26	27
24		150	78	190	20.8	2.00	8.60	32	5.85	25.5		24	21	
2		360	170	200	25	20	64	8	24	27	24	20	47	
Aver.	8.7	96	200	174		2.20	26	40	2.2	2.7	2.64	20.2	2	

erative levels, but in 4 cases were higher in the 3 hour postoperative samples. This latter finding probably indicates rapid loss of transfused saline from the circulation. The average plasma proteins were 6.32 grams per cent before operation and fell to 3.47 grams per cent 3 hours after operation. Subsequent 6 and 24 hour samples showed averages of 3.65 grams per cent and 4.40 grams per cent. The hematocrit readings, on the other hand showed less change due to the washed red cells in the transfusion fluid. The preoperative hematocrit average was 42.2 and fell slowly to 31.6 over the next 24 hours. Thus the blood proteins were severely depleted whereas the red cell volume was little affected by the experimental procedure. The slight rise in blood plasma protein probably was due to release of protein from the animals' labile protein reserve stores.

The *heparinized plasma* experiments in Table III were somewhat of a surprise. The first 8 dogs showed 3 deaths and 5 survivals, and it appeared that they had only a 60 per cent chance of survival. Of the next 7 dogs, however, 6 survived. These later dogs were of the same type; there was no change in the technique and the amount of bleeding was comparable to all the others. The dogs of this series did not seem to recover as quickly as those in either the red cell or saline series while on the operating table. Their postoperative recovery required a longer period of time than

that of the dogs which received washed red cells. While the plasma proteins remained within normal range the hematocrits were reduced 50 to 75 per cent and showed little change during the subsequent 24 hours. The average preoperative plasma proteins were 6.34 grams per cent and in the 11 dogs that survived showed an average of 6.09 grams per cent 24 hours after operation. The average preoperative hematocrit was 39.1 per cent and this was reduced to the average of 12.0 per cent 3 hours after operation. After 24 hours it still only averaged 12.4 per cent in the 11 surviving dogs. Hence these dogs survived despite the marked experimental acute anemia.

Autopsy data are not included in the tables since it may be said that no uniform or characteristic abnormalities were found. Dogs in the saline transfusion and heparinized plasma transfusion experiments showed pallor of the viscera and tissues in all cases. Round and tape worms were occasionally encountered in the intestine. Dog No. 33 had been previously used in some hemoglobin experiments and a toxy revealed a grossly brown pigmented liver. Microscopically both the parenchymal and Kupffer cells contained many yellow brown pigment granules. Similar pigment was found in the epithelium of a few kidney tubules. Dog No. 25 showed vegetations on the tricuspid valve with abscesses and infected infarcts of the kidneys. Microscopically the vegetations showed early organization and

TABLE III.—HEPARINIZED PLASMA TRANSFUSIONS

Dog No	Wt	Vol of blood removed		Amt of saline perfused	Vol removed after perfusion	Total protein removed		Preoperative sample		3 hour sample		6 hour sample		24 hour sample		Observations
		kgm	cc.		cc	gm	gm/kgm	P P	Hemat.	P P	Hemat.	P P	Hemat.	P P	Hemat.	
26	12 0	580	275	350	44 1	3 67	6 40	43 0	5 22	7 80	5 78	8 2	6 36	11 4		Survived
27	11 3	475	260	250	40 1	3 54	6 50	34 5	6 16	0 40	6 47	10 0	6 67	12 1		Survived
28	8 0	280	184	230	22 4	2 80	5 86	40 2	4 37	13 2*						Dead—2 hrs
29	13 0	600	300	350	46 0	3 60	6 44	40 0	6 50	6 10*						Dead—1½ hrs
30	8 6	300	198	210	27 0	3 10	6 22	45 0	5 09	12 8	5 77	12 2	7 00	13 0		Survived
31	10 5	430	240	300	34 4	3 30	5 77	47 1	4 81	17 6	5 14	10 0	5 88	17 4		Survived
32	13 9	660	320	360	42 9	3 10	5 30	40 1	4 07	17 6	5 05	17 6	5 07	14 6		Survived
33	9 3	350	214	200	28 8	3 10	6 31	25 4	4 01	7 50						Dead—2½ hrs
34	11 6	550	270	375	44 8	3 00	6 57	37 6	5 60	11 0	5 60	10 0	6 30	13 0		Survived
35	9 8	425	225	205	36 2	3 70	6 40	42 4	5 10	12 1	5 40	11 3	6 20	12 2		Survived
36	11 1	625	255	350	48 7	4 40	6 72	40 0	5 66	13 7	5 60	11 5	5 32	10 1		Survived
37	11 7	500	270	350	37 4	3 20	7 30	41 3	6 50	8 50	5 88	10 5	6 57	10 1		Survived
38	6 4	310	146	190	26 0	4 20	6 90	42 9	5 20	16 0	5 05	14 5	5 80	14 3		Survived
39	6 8	375	156	200	26 5	3 00	5 78	32 5	5 28	11 1	5 53	10 8	5 80	11 0		Survived
40	7 6	250	175	240			6 70	25 0	5 73	10 0	5 88	11 2				Dead—9 hrs
Aver	10 1	447	232	283	36 2	3 51	6 34	39 1	5 47	12 0	5 59	12 2	6 09	12 4		4 died 11 survived

*Samples taken 1½ hours after bleeding (not included in average)

the abscesses and infarcts appeared to be several days old. We believe that the abnormal findings of these 2 dogs preceded our experiments. No findings of significance related to the shock response were observed in any of the other animals.

OBSERVATIONS

The almost complete failure of the single infusion of saline to maintain the animals beyond a short initial period is a common experience. When both red cells and plasma protein are reduced to the levels indicated in the tables, the animal organism has no resistance to the state of shock, even though its blood volume is replaced immediately by an adequate amount of normal saline. The animal appears to suffer from the anoxia of anemia, and even though mild hemoconcentration and partial replacement of plasma protein occurs the dog rapidly becomes weaker and dies.

The success of the series in which red cells suspended in saline were used, appears to be due to the immediate replacement of the oxygen carrying capacity of the blood, thereby preventing the occurrence of a severe anoxia.

The spectacular recovery of these animals from a condition of shock, fully as profound as that observed in the animals (Tables I and III) that subsequently expired, indicates that the red cell replacement may be of fundamental importance in overcoming hemorrhagic shock. Recovery was the invariable rule when the blood removed was replaced with red cells suspended in saline, whereas replacement with saline alone was accompanied by 80 per cent fatality. Plasma protein levels were equally low in both these series, and plasma protein replacement, therefore, appears less important than red cell replacement.

The poorer results obtained when the volume of the primary bleeding was replaced by heparinized plasma further emphasizes the importance of red cell replacement. The animals of this series were longer in recovering, and 27 per cent died. In the series where the blood was replaced by saline alone, the solution was inadequate to keep the animals alive, even though the hematocrits were often slightly higher than in a successful case in which plasma was used. Blood volume studies were not done, but we feel that there can be little doubt

that plasma replacement is more satisfactory than saline replacement because with the former procedure the blood volume is maintained whereas, with saline replacement the animal must adjust both to anoxia and a shrinking circulatory volume. But the maintenance of the level of the circulating plasma protein at a figure approximating the normal still appears less effective in combatting shock due to a single severe hemorrhage than the reestablishment of the red cell volume of the circulation.

SUMMARY

1. A simple easily duplicated method for producing hemorrhagic shock in dogs is presented. Under local anesthesia, the femoral artery and vein are cannulated. The animal is bled from the artery until the blood flow has practically ceased and then perfused with 25 cubic centimeters per kilogram of 0.9 per cent sodium chloride solution through the vein to wash out more red cells and plasma. When the bleeding has again practically ceased the artery is ligated and the volume of test solution equivalent to the first bleeding given immediately into the vein. Following this the vein is ligated and the wound is closed.

2. In these experiments washed red cells suspended in isotonic saline are found to be

more effective than either normal saline alone or heparinized plasma, in overcoming shock produced by a single severe hemorrhage.

3. Replacement of the oxygen carrying capacity of the blood appears to be more important than the restoration of the normal plasma protein level under the conditions of these experiments.

4. As an emergency measure isotonic saline is shown to be effective in promoting temporary recovery from hemorrhagic shock as produced by a single massive hemorrhage.

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ADMINISTRATION OF ALKALIS IN SULFADIAZINE THERAPY

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IT has been shown experimentally and clinically that the renal complications of sulfadiazine therapy can be prevented by the production and maintenance of an alkaline urine (2, 3, 4, 5). Other investigations have shown that an alkaline urine can be maintained by giving from 4 to 19.5 grams of sodium bicarbonate daily.

Bywaters reported in 1942 the use of one-sixth molar sodium *r*-lactate intravenously for the production of alkaline diuresis. Gilligan and her associates (3) reported in 1943 on 23 surgical patients receiving 5 grams daily of sodium sulfadiazine intravenously. In these 23 cases the incidence of crystalluria was 43 per cent, and all of the specimens of urine which contained crystals were acid. These authors also reported 2 cases in which 1,000 cubic centimeters of one-sixth molar sodium *r*-lactate was given daily, with alkaline urine and no crystalluria.

Since immediately after operation patients cannot be given oral medication, it was thought desirable to determine a practicable method for rapidly producing alkaline urine for the safe intravenous administration of sodium sulfadiazine and for keeping the urine alkaline up to the time that sodium bicarbonate could be given orally.

In 20 cases following operation the pH of 422 specimens of urine was determined, beginning 24 hours prior to and continuing for 5 days after starting alkaline therapy. Each specimen was tested with nitrazine paper¹ within a few minutes after being voided. If the patient had an indwelling catheter, fresh urine from the catheter was tested every 4 to 6 hours. Specimens were examined microscopically at least once daily for sulfadiazine crystals, red blood cells, and casts. Deter-

minations of the carbon dioxide capacity of the blood were made at least once in each case.

Chart 1 shows the pH determinations for 65 specimens of urine from 5 patients, ranging in age from 17 to 65 years. These patients had undergone the following operations: appendectomy, 2 cases; transurethral resection of the prostate, 1 case; splenectomy, 1 case; and repair of an inguinal hernia, 1 case. Sodium bicarbonate, 60 to 240 grams, was given daily in order to determine the time and dosage necessary to establish and maintain urinary alkalinity. It was found that an average of 22 hours was required to establish urinary alkalinity. Daily administration of 240 grams of sodium bicarbonate² in 4 divided doses in water was the lowest dosage which would keep the urine alkaline. The highest carbon dioxide capacity was 71 volumes per cent after 8 days of administration of 24 grams of sodium bicarbonate daily, and the lowest was 49 volumes per cent on the first day of alkali therapy. Therefore, if the surgeon wishes to use sulfadiazine therapy without danger of renal complications he must wait the number of hours necessary for tolerance of oral administration of sodium bicarbonate plus 22 or more hours for the establishment of urinary alkalinity.

Chart 2 shows the pH determinations for 145 specimens of urine from 7 patients, ranging in age from 29 to 70 years. These patients had undergone the following operations: appendectomy, 2 cases—in 1 case the appendicitis was acute, with gangrene and localized peritonitis and, in the other there was acute appendicitis with abscess; nephrectomy, 1 case; repair of an inguinal hernia, 1 case; cholecystectomy, 2 cases; and cystotomy for *Escherichia coli* peritonitis from urinary extravasa-

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¹Nitrazine paper (sodium dinitrophenol azo-naphthol disulfonate). E. R. Squibb & Sons.

²When 1 level teaspoonful of sodium bicarbonate is given 4 times a day approximately 24 grams is the total dosage.

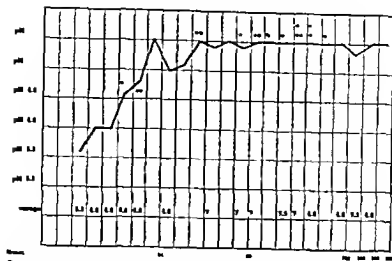


Chart 1. Urinary pH of 65 specimens of urine from 3 patients after operation. Zero hour indicates the beginning of oral administration of sodium bicarbonate.

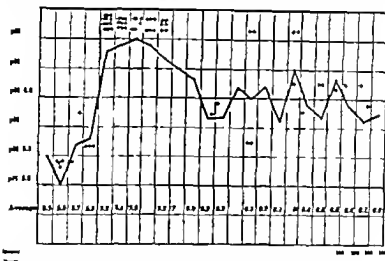


Chart 2. Urinary pH of 45 specimens of urine from 7 patients. Zero hour indicates completed intravenous administration of 1,000 cubic centimeters of one-sixth molar sodium lactate.

tion 1 case. On the first postoperative day each patient received 1,000 cubic centimeters of one-sixth molar sodium γ lactate¹ intravenously. 2 patients received it for 2 days, 1 for 3 days and 1 for 4 days. The last mentioned patient was given a total of 5,500 cubic centimeters of one-sixth molar sodium γ lactate

intravenously. The urine was alkaline in the majority of cases by the time the intravenous injection was finished and in all cases it was alkaline 3 hours afterward, remaining so for an average period of 24 hours. The highest carbon dioxide capacity was 76 vol. per cent after 4,500 cubic centimeters of one-sixth molar sodium γ lactate had been given over a period of 4 days. The lowest was 47 volumes

¹Each 100 cubic centimeters of one-sixth molar sodium lactate contains 300 grams of sodium lactate.

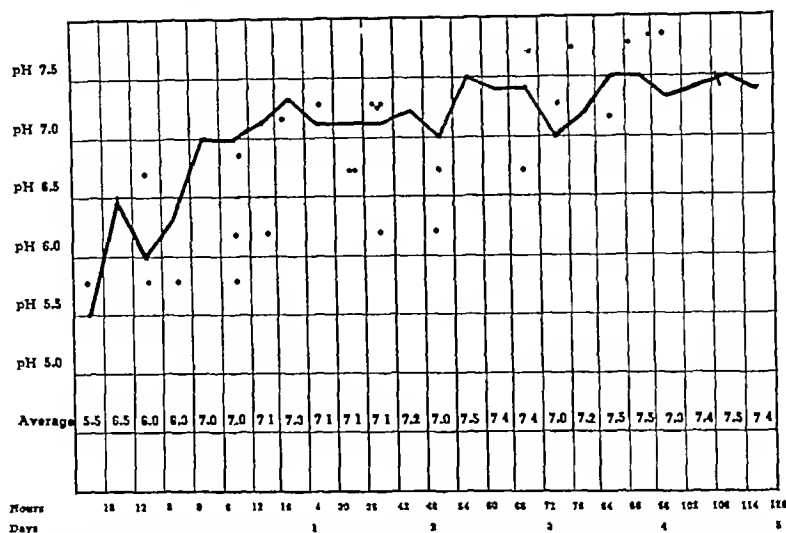


Chart 3 Urinary pH of 212 specimens of urine from 8 patients who were given 1,000 cubic centimeters of one sixth molar sodium r lactate intravenously daily after operation, followed by sodium bicarbonate orally when tolerated. Zero hour indicates completion of intravenous administration of 1,000 cubic centimeters of one sixth molar sodium r lactate.

per cent and was recorded on the 4th day for the patient receiving 3,000 cubic centimeters. One patient received 40 grams of sodium sulfadiazine intravenously over a 6 day period. Daily for 6 days 1,000 cubic centimeters of one-sixth molar sodium r-lactate was given, and no crystals in the urine or other renal complications developed. Another patient received 25 grams of sodium sulfadiazine intravenously without renal complications or crystalluria.

Chart 3 shows the pH determinations for 212 specimens of urine from 8 patients, after operation, who were given one-sixth molar sodium r-lactate intravenously followed by sodium bicarbonate orally as soon as tolerated. Their ages ranged from 4 to 71 years. These patients had undergone the following operations: appendectomy, 5 cases—in 2 cases there was acute appendicitis with perforation and *Escherichia coli* peritonitis, in 1 case acute appendicitis with perforation and localized peritonitis, in 1 case acute appendicitis with gangrene, and in 1 case acute appendicitis with abscess, repair of an inguinal hernia, repair of an incisional hernia, and cholecystectomy. This chart shows, as did Chart 2, that by the intravenous administra-

tion of 1000 cubic centimeters of one-sixth molar sodium r-lactate urinary alkalinity was promptly established, and by the administration orally of sodium bicarbonate the alkalinity was maintained. The carbon dioxide capacity ranged from 40 to 75 volumes per cent. The dosage of sodium bicarbonate was from 3 to 30 grams daily. Again, 24 grams of sodium bicarbonate in 4 divided doses was the smallest amount that would consistently keep the urine alkaline. Six patients were given a total 5 day dosage of 50 to 315 grams of sulfadiazine orally and sodium sulfadiazine intravenously. A few red blood cells were observed microscopically in 3 specimens of urine in this group. There were no sulfadiazine crystals.

A 4 year old patient with severe *Escherichia coli* peritonitis was given 1000 cubic centimeters of one-sixth molar sodium r-lactate intravenously daily for 2 days, with 175 grams of sodium sulfadiazine intravenously daily for 2 days followed by sulfadiazine and 60 grams of sodium bicarbonate orally daily. In this case the highest carbon dioxide capacity was 60 volumes per cent and the lowest 53 volumes per cent. There were no sulfadiazine crystals present.



Chart 4. Urinary pH determinations for patients with infection (A) compared with the pH determinations for those without infection (B). Zero hour indicates completion of intravenous administration of 1,000 cubic centimeters of one-sixth molar sodium lactate.

One patient who did not receive sodium r lactate after operation had had sulfathiazole placed in the abdomen at operation, and 3 days later oliguria, abdominal pain hematuria, and heavy sulfathiazole crystalluria developed, all of which promptly disappeared after administration of 1,000 cubic centimeters of one-sixth molar sodium r lactate intravenously and 30 grams of sodium bicarbonate by mouth for 2 days.

Sodium sulfadiazine precipitates with one sixth molar sodium r lactate when mixed in the flask or in the intravenous tubing. Therefore, our method was to add 300 cubic centimeters of normal saline solution to the intravenous set when the one-sixth molar sodium r lactate had been given and after 200 cubic centimeters of normal saline solution had been given to add sodium sulfadiazine to the remaining 300 cubic centimeters of saline solution. Ampuls containing 10 cubic centimeters of 25 per cent solution of sodium sulfadiazine were used. If additional glucose and fluids were desired, 5 or 10 per cent dextrose in lactate Ringer's solution was given and if several days of intravenous administration of fluids was anticipated 1,000 cubic centimeters of

amigen daily was often given intravenously to supply protein.

Chart 4 shows the pH determinations for 7 patients after operation with moderate to severe infection compared with those for 8 patients with minimal or no infection. Clinically the patients with infection required more alkali to produce and maintain alkalinity of the urine.

Schnelles has reported that the pH of infected wounds is between 5 and 6 while that of clean wounds is 7.3. He has also shown that measured against certain organisms, one tenth as much sulfathiazole will overcome 1 mol of the sulfonamide inhibitor para-aminobenzoic acid at pH 7.5 as at pH 5.0. Clinically we have observed that surgical patients with severe infection have recovered very rapidly with sulfadiazine and alkali therapy.

SUMMARY AND CONCLUSIONS

- 1 The pH determinations for 422 specimens of urine from 30 patients after operation were analyzed.
- 2 One-sixth molar sodium r lactate intravenously was shown to be efficient for the rapid production of urinary alkalinity.

¹Lactate-Ringer solution contains in each 100 cubic centimeter: 5.0 gram sodium chloride, 1.0 gram sodium lactate, 0.5 gram potassium chloride and 0.5 gram calcium chloride.

²Five per cent solution of amigen, of dextrose, sterile serum solution of an anhydrous hydrolyzate of peptone, and 5 per cent solution of 5% per cent solution of dextrose, adjusted to pH 7.0. Medco Laboratories, Inc.

3 It was found that 1,000 cubic centimeters of one-sixth molar sodium r-lactate maintained urinary alkalinity for an average of 24 hours

4 At least 24 grams per day of sodium bicarbonate was necessary to maintain urinary alkalinity after the intravenous administration of fluids was discontinued

5 Renal complications were not found after sulfadiazine administration when the urine was rendered alkaline

6 Sodium sulfadiazine should not be mixed with or come in contact with one-sixth molar sodium r-lactate in the intravenous set

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A CLINICAL SYNDROME ASSOCIATED WITH A RARE ANOMALY OF THE VENA PORTAE SYSTEM

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ANOMALIES of the portal vein are rare. Instances have been recorded in which the portal stream has been conveyed to the liver in two channels, such findings are of interest to the anatomist, but on no occasion has it been recorded that the anomaly has been associated with symptoms or physical signs indicative of a disease syndrome. Recently a case came under observation presenting what must be a very uncommon disposition of the venous channels of the portal system, and as the anatomical findings were associated with a distinctive clinical picture the occurrence may be thought worth of record.

Mrs. A. W., aged 3 years, quadrupara, was admitted to the Edinburgh Royal Infirmary on account of jaundice associated with increasing general debility. She stated that, subsequent to the birth of her last child, seven months before she experienced progressive deterioration in body strength and ability. Associated with these general features there was feeling of distension and heaviness in the abdomen, particularly after meals, and from time to time vomiting occurred, this afforded temporary relief from the feeling of distension. There were frequent and copious stools, and the patient noted that the bowel matter was consistently pale and, indeed, often clay-colored. Sometimes there were attacks of diarrhoea, considerable in amount and crumbly in appearance. Loss of eight pounds noticeable and the decline in strength and energy, the appetite deteriorated, anorexia developed combined with pronounced distastefulness for any food of fatty nature. Four weeks before the patient's admission to hospital jaundice appeared. At first it was slight and evanescent, latterly it became persistent and more intense. The menses, hitherto regular in incidence and normal in amount, diminished in quantity and for 3 months before admission to hospital there was complete amenorrhoea.

The patient was slightly built and somewhat ill-nourished. On admission there was general evidence of moderate degree of the appearance depressed and exhausted, and it was evident that a serious degree of illness existed. On the other hand, the temperature and pulse rate were normal, the tongue was clean and moist.

The respiratory and cardiovascular systems showed no evidence of disease. A blood examination gave the following findings: red blood cells, 4,300,000; haemoglobin, 55 per cent; color index, 1.0; white blood cells, 4,400. The red corpuscles showed marked anisocytosis, hypochromic and hyperchromic cells being in about equal proportions, the platelet count as normal and differential white cell count gave approximately correct readings.

The urine reaction was acid, albumen, sugar and acetone were absent, but bile was present in considerable amount. The nervous system was healthy and the Wassermann reaction was negative.

The main interest centered around the examination of the alimentary system. Considering the degree of general malnutrition the abdomen was unduly protuberant, and inspection showed that this was the result of intestinal distention. It was thought that small amount of free fluid as present but this observation was uncertain. There was some tenderness accompanied by muscle rigidity in the upper right quadrant of the abdomen, the lower border of the liver could be palpated immediately beneath the right costal margin, its outline as smooth and normal, the gall bladder did not appear to be distended. There was an appreciable degree of splenomegaly, the anterior border and lower pole of the organ could be palpated at a distance of 4 inches below the left costal margin, the outline was smooth and uniform, and the notch easily perceptible. The rectal examination was negative.

A straight x-ray examination showed considerable degree of gas distension of small and large intestines. It confirmed the clinical observation that splenomegaly existed. It revealed no evidence of calcification formation in any part of the biliary tract.

A barium meal and barium enema examination were carried out, the results, in view of the evidence of jaundice it was thought inadvisable to attempt special (S.T.L.P.P.) investigations.

Splenic investigations. The blood urea nitrogen was 15 milligrams per cent (Van Slyke). The icteric index, estimated by the Mroczkowski method, was 67. The anion-Berg test was reported as showing direct biliary reaction. Examination of the stool showed an increased proportion of unsplit fat. The readings were: total fat, 6.4 split fat, 35 unsplit fat, 64. It was noted that the feces contained number of fat globules, these were particularly evident when diarrhoea occurred, and it was obvious that their presence explained the creamy appearance of the stool at these times. Analysis of the gastric juice gave the following readings: total acidity, free acidity.

The pancreatic diagnosis. The patient, as admitted to hospital on provisional diagnosis of pancreatic disease either as a neoplasm of the body of the pancreas, which beginning to involve the head of the organ, or chronic pancreatitis. This diagnosis was based upon various features in the clinical history, the increasing general debility accompanied by loss of weight, the gastric disturbance indicated by loss of appetite, flatulence and vomiting, the diarrhoea, the character of the stools, the late stages of the illness the development of an obstructive jaundice appeared, and confirmed to the view that pancreatic disease existed.

The chemical investigation while not confirmatory appeared to support this diagnosis, but one conference known was the splenomegaly. The explanation and significance of the feature were obscure and was difficult to resolve. The part played in the clinical picture.

Now we have little recognizing that there are many instances, the bulk of the evidence supported the diagnosis of pancreatic disease, probably malignant in character, as decided therefore that the case was justified explanation by operation. It was considered that this afforded the only

means by which an accurate diagnosis could be arrived at, and it was thought that, if the position could be clarified, a way might be found of affording at least a temporary relief of symptoms.

Prior to operation certain preliminaries were carried through the prothrombin element of the blood was reinforced by the administration of vitamin K (intramuscular injections of kapilon 1 c c 4 hourly over a period of 48 hours), while, in view of the leucopenia, a small transfusion of blood (500 c c) was given 12 hours before operation.

Findings at operation The abdominal cavity was entered through a right upper paramedian incision. The peritoneal space contained a quantity of fluid which was faintly bile stained, though appreciable in amount, it was not excessive.

On proceeding to examine the viscera interest was focused on the appearance presented in the subhepatic region. Beneath the peritoneum in relation to the right gastropancreatic fold of peritoneum and the lesser omentum and along the line of the hepatic and common bile ducts, there were a number of bluish, fluid-containing saccules. On first impressions the condition appeared to be one of multiple cysts of the bile ducts, but, when the peritoneum was divided and stripped off, it was seen that the saccules were venous in origin and that the state was one of a tortuous multiform varix showing cystlike dilatations at many points. Further dissection established the identity and relationships of the plexus caudally it was in communication with the superior mesenteric vein, the right half of the splenic vein shared in the varicosity, and there seemed to be no doubt that the venous stream from the spleen communicated with the varix. In its relationships and associations, therefore, it appeared to correspond to the distribution of the portal venous stream (Fig 1). An attempt was made to ascertain whether a portal vein existed in the normal situation, but the varicosity made the dissection difficult and indeed dangerous. The ultimate exposure was not satisfactory, but it was established that a portal vein of small size lay in its normal relation on the posteromedial aspect of the common bile duct.

A review of the abdominal viscera brought out some interesting facts. The liver was normal in size and appearance, the gall bladder was smaller than usual, its wall was thickened and edematous and the distribution of the cystic vein showed a miniature varicosity, there were no gall stones. The biliary system was healthy, and, so far as could be ascertained, there was no abnormality of the arterial distribution. The appearances and consistency of the pancreas suggested that it was the site of a mild degree of diffuse chronic pancreatitis. The spleen was enlarged to twice the usual size, its surface was smooth and uniform, its consistency firm, in general its appearance suggested that it was the site of a chronic venous congestion with secondary fibrotic changes.

No gross structural changes were apparent in the stomach or in the segments of the small and large bowels which could be brought under review, but these organs presented a congested appearance, while here and there patches of subperitoneal edema were apparent. The impression given was that there was a considerable degree of venous engorgement throughout the area drained by the portal stream.

Reviewing the situation in the light of the operation findings, it appeared that the condition presented in the subhepatic region was a true varix of an abnormal portal vein distribution. The anatomical interest of the anomaly and the explanation of the part which it played in the clinical pic-

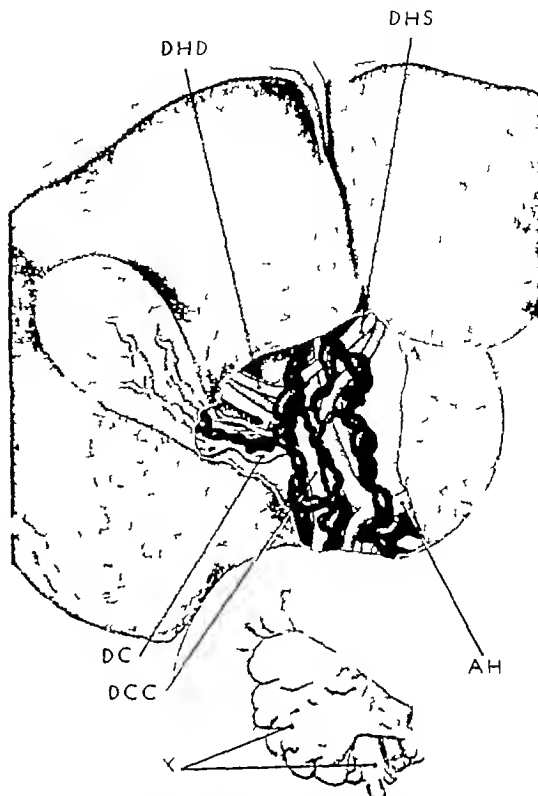


Fig 1 The appearances of the portal varix as revealed at operation. DHD, Right hepatic duct, DHS, left hepatic duct, DC, cystic duct, DCC, common bile duct, X, part of pancreas and superior mesenteric vein.

ture are discussed in the commentary, the immediate problem of the moment was to decide upon the means by which the situation could be relieved. It seemed that only one course was possible—to ligature and if possible to eradicate the dilated and abnormal channels, trusting that the sequel would be to divert the portal venous return into the small, but otherwise normal, vessel. It was assumed that the concentration of the flow into a single channel would be followed by a degree of dilatation adequate to accommodate the increased bulk of blood. The plan was put into operation. It proved difficult, for the dilated venous radicles were extremely thin walled, many of them ruptured when an attempt was made to separate them, and, indeed, the degree of hemorrhage was disconcerting. In order to secure adequate access to the higher portion of the varix it was necessary to remove the gall bladder, but even so the difficulties in the immediate subhepatic region were so great that gauze packing

had to be resorted to before the bleeding could be controlled. Eventually hemostasis was satisfactory and complete and, after drainage was established by means of a strip of dental rubber the abdominal wound was closed.

Postoperative progress. The patient's progress after operation was excellent and satisfactory. The jaundice diminished and by the end of the third week all traces of pigmentation had disappeared. An icteric index examination during the fourth week yielded a normal reading (4). An interesting response was recorded in the blood picture: the preoperative leucopenia (4,000) was replaced by leucocytosis, the blood readings one week after operation being: red blood cells, 5,650,000; hemoglobin, 68 per cent; white blood cells, 3,000. Equally satisfactory as the leucocytosis in the general condition. The appetite returned, the stools became normal in occurrence and in appearance, all sense of abdominal discomfort and distention disappeared, and the weight increased. The patient is discharged from hospital in good health 9 weeks after operation, and since that date, now 8 months ago, her progress has been satisfactory.

It seemed beyond doubt or question that the anomalous venous channels lying in relation to the right gastropancreatic fold of peritoneum and to the lesser omentum represented an abnormal and accessory distribution of the portal vein. Their identity was established on several grounds: their beginnings could be traced in continuity with the splenic and superior mesenteric veins, their ultimate distribution was into the *porta hepatis*; they occupied an area in which the portal channel is the sole venous representative. It is true that their anatomical relations to the bile duct and the hepatic artery were abnormal; several of the channels were superficial to these structures, others intertwined around and among them, but the relation of a varix to adjacent tissues is invariably indefinite and in this instance a disturbance of the usual relations was a natural consequence of the abnormality.

Having identified the anatomy of the varix, it was natural to enquire about its origin. One thing seemed to be clear—it represented a developmental abnormality. In all probability a persistence of certain portions of the embryonic and fetal venous dispositions from which the portal vein arises. Doubtless the stress and strain of postnatal life had played a part in creating the varicosities, but it was surely an inescapable conclusion that the origin of the condition could be traced to the persistence of fetal portal radicles.

The portal vein arises from certain modifications and adjustments of the right and left vitelline veins, the channels which at an early stage of development convey blood from the yolk sac portion of the entodermal vesicle to the primitive ventral aortae, and at a later stage of develop-

ment to the sinus venosus of the primitive heart. With the delimitation of the duodenum the vitelline veins come to lie to the right and left of this portion of the foregut. In this situation they are united by three transverse channels, two of which lie ventral and one dorsal to the gut so that the arrangement resembles a venous ladder extending along the duodenum and in the caudal direction passing into the substance of the developing liver where they form the channel of the sinusoidal system. As development proceeds, certain segments of the vitelline venous ladder degenerate and disappear but three portions remain—the cephalic end of the left limb of the caudal loop between the vitelline veins, the dorsal intervitelline channel, and the right limb of the cranial-ward loop. It is from a continuity of these three elements that the portal vein arises, and the link between the visceral field is completed almost simultaneously when the superior mesenteric and splenic veins establish communication with the left vitelline vein at a point immediately caudal to the dorsal transverse anastomosis (Fig. 2).

Such being the normal arrangement, how is the anomaly under discussion to be explained? Various possibilities present themselves: (1) the persistence of the right vitelline vein as an independent channel; (2) the existence of a double right vitelline vein, one branch entering into the formation of the *vena porta* while the other retained its independence; (3) the persistence of the caudal segment of the right vitelline vein. The relations and disposition of the varix were not in keeping with the third explanation, for in this event one would have expected that the cephalic end would have opened into the main portal vein. The fact that it passed into the liver through the *porta hepatis* suggested that it represented either the right vitelline vein in toto or a independent radicle of an abnormal twin structure. No doubt in their beginnings the abnormal radicles were but slender and miniature structures, as growth proceeded they underwent enlargement, and it is probable that for a time they provided channels of conveyance which functioned relatively normally. Then came the stage of ancolity and sacculle formation and it may be presumed that these reactions were dependent upon variety of influences. The wall of the portal vein presents peculiar features. The main constituent is areolar tissue; the muscle is not arranged as a continuous sheet but as a series of bands separated by strands of fibroareolar tissue. It is probable that in abnormal radicles of the portal series these peculiarities of structure are exaggerated and, also, the liability to dilatation was likely to be increased. It

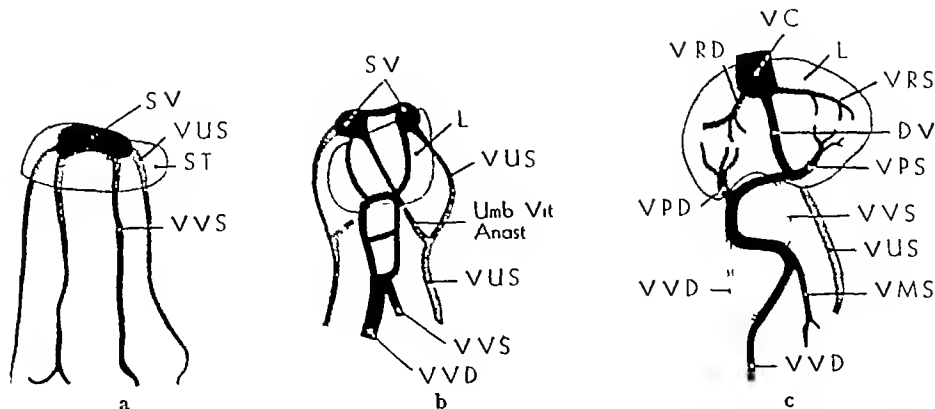


Fig 2 The development of the portal system. The probability is that the anomaly recorded represents either persistence of portions of the right vitelline vein or of independent radicles of an abnormal twin structure.

a, *SV*, Sinus venosus, *VUS*, left umbilical vein, *ST*, septum transversum, *VVS*, left vitelline vein.

b, *SV*, Sinus venosus, *L*, liver, *VUS*, left umbilical vein, *Umb Vit Anast*, *VUS*, left umbilical vein, *VVS*, left vitelline vein, *VVD*, right vitelline vein.

c *VC*, Upper or cephalic part of inferior vena cava, *VRD*, right vena revehens, *L*, liver, *VRS*, left vena revehens, *DV*, ductus venosus, *VPS*, left branch of portal vein, *VLS*, atrophied part of left vitelline vein, *VUS*, left umbilical vein, *VMS*, superior mesenteric vein, *VVD*, right vitelline vein, *V'VD'*, atrophied part of right vitelline vein, *VPD*, right branch of portal vein. (Reproduced by permission from Cunningham's *Textbook of Anatomy*.)

may be argued too that the mode of distribution of the portal vessels encourages a tendency to varicosity if structural weakness of the wall exists; they terminate, as arteries do, in a capillary system, an arrangement which is likely to raise the pressure within the afferent channels. It is probable that these influences played a predisposing part, and it may be that they initiated the early stages of varicosity, but it seems evident from the clinical history that an additional element came into play, the result of which was to lead to a rapid and exaggerated development of the varix, it is suggested that this precipitating factor was the succession of four pregnancies within a period of 5 years. No doubt the effect of these developments was to increase the strain upon the portal circulation, and it may be assumed that the consequences led to exaggerated varicose changes in the weak and abnormal segments of the portal channels. On a basis such as this it is possible to visualize a state of affairs which initiated the error and led ultimately to a gross degree of varicosity.

From the clinical standpoint there is special interest in visualizing the part which the varicose anomaly played in the case history and physical findings. It seems that there can be but one explanation—that the varix was responsible for a progressive and, indeed, an acute degree of portal stasis. In some respects the clinical picture bore a resemblance to that encountered in cirrhosis of the liver—the loss of weight and impairment of

strength, the increase of peritoneal fluid, the splenic enlargement, the gastritis and enteritis, the recurrent jaundice, all of these were present, and, if the liver had shown fibrotic changes, the picture would have been reasonably complete, but in this instance the liver was healthy, and it was evident that the obstructing element was the abnormal and varicose portal vein distribution.

The manner in which it exerted its effect must be a matter of conjecture, but it seems reasonable to advance the argument that the condition offered a parallel to that which exists in varicosity of the superficial veins of the lower extremity. It is agreed that in the latter instance the varix presents a definite hindrance to an efficient venous circulation, the blood flow within it is apt to be static and inert, and, while the relative increase in the capacity provided is likely to attract blood from contiguous and related channels, the ultimate result is to create a catchment area in which blood tends to stagnate, a state of affairs which prejudices the efficiency of the related circulation and vitiates the health of the tissues from which the blood intake is derived.

As we see it, that is the situation which arose in the case under discussion. It meant that a progressive and relatively acute degree of portal stasis came to be established, obstruction of the venous return from the spleen led to the splenomegaly, venous congestion of the stomach and duodenum accounted for the vomiting, the gastric distention, and the various dyspeptic symp-

toms a similar development in the area of the pancreas disturbed the physiological activity of that organ with consequent derangement of the digestion of fats and starches. Secondary to the congestion and edema of the head of the pancreas a catarrhal cholangitis developed the feature which explained the jaundice; parallel changes in the small intestine appear to have interfered with fat absorption by the lacteals, so that a form of steatorrhea resulted—indeed the entire clinical picture subjective and objective can be interpreted in terms of a relatively acute portal obstruction.

One consideration remains for discussion. It may be put in the form of a question. Why should the obliteration of the varix result in the disappearance of symptoms? That it has done so permanently indicates that it led to a relief of the state of portal congestion, but the pertinent question is how this was achieved. It may be that the answer is provided in the parallel already alluded to—varicosity of the superficial veins of the lower extremity. It is clear that in this affection obliteration of the dilated superficial channels leads to

an improvement in the circulatory condition of the limb. It does so by returning into active circulation a volume of blood which otherwise would remain in a condition of physical and physiological inertia, and by so doing it benefits tissue nutrition and the tone and pressure of the circulation. This explanation and reasoning are surely equally applicable to the condition under discussion. Indeed, it would be difficult to suggest a better solution, and therefore we assume that the obliteration of the varix resulted in the re-establishment of a healthier portal circulation and the restoration of the physiological balance of the tissues in the portal field.

SUMMARY

An account is given of the case history and clinical findings associated with a rare anomaly of the development of the vena portae—varicose changes in the abnormal vessels resulted in a state of subacute obstruction in the portal circulation with the presentation of a consequent disease syndrome. Obliteration of the varix was followed by relief of the obstruction and the disappearance of the clinical syndrome.

HEALING OF THE ABDOMINAL WALL AFTER LOOP COLOSTOMY

An Experimental Study

ALEXANDER SLIVE, M D , M Sc. (Med), DAVID SHOCH, Ph D , and
SAMUEL J FOGELSON, M D , F A C S , Chicago, Illinois

IN order to avoid such complications as peritonitis, cellulitis of the abdominal wall, and evisceration, surgeons endeavor to defer the opening of a loop colostomy until they believe that healing between the bowel and abdominal wall is complete enough to prevent these sequelae. When intestinal obstruction is absent, there is no urgency about opening the loop of bowel, and the problem is obviated. In complete, acute obstructions, however, the desirability for the earliest possible drainage must be balanced against the chance that contaminating organisms might cause an infection of the peritoneal cavity or abdominal wall. Surgical opinion varies as to the safest time for opening a loop colostomy. Rankin and Graham state "After 48 hours, the natural reparative powers of the tissues seal off the peritoneal cavity and it is safe to open the bowel. This, however, is best postponed for 6 or 7 days."

The object of this experiment was to evaluate quantitatively at various times after operation the strength of union between the colon loop and abdominal wall in animals with loop colostomies.

METHODS

The following operation was performed on 48 dogs. A loop of colon was delivered through a right transrectus incision 4.5 centimeters long and placed halfway between the pubis and xiphoid process. The afferent and efferent limbs of the exteriorized loop were united with four interrupted silk seromuscular sutures placed 1 centimeter apart. This procedure was employed to prevent other segments of intestine from entering the space between the two limbs of the colostomy loop, and also because this technique is a frequent clinical practice when spur formation and a temporary colostomy is desired. The peritoneum and the anterior rectus sheath were each united with four interrupted chromic 20 day No. 000 sutures, two above and two below the colon loop. The skin edges were closed in the same manner, four

silk sutures being used. As no sutures were used between the bowel and abdominal wall, retraction of the loop into the peritoneal cavity was prevented by perforating the mesocolon with a piece of rubber tubing placed external to the skin.

The strength of the healing process between the colon loop and abdominal wall was determined by inserting a 14-gauge needle through the abdominal wall into the peritoneal cavity on the side opposite the colostomy. The needle was connected by a rubber tubing to a bicycle pump through a large mercury manometer. Then, with the dog's trunk held under water, the peritoneal cavity was inflated and the pressure noted at the moment air bubbles appeared, indicating leakage between the abdominal wall and the colostomy loop.

The nearness of the peritoneal and fascial sutures to the bowel loop varied slightly with the size of the bowel, in order to secure a snug closure around the loop. The same surgeon performed all the operations, and it was endeavored to secure a reasonably similar mechanical tension around the exteriorized loop of colon throughout the experiment. A relatively large series of animals was used to diminish the element of chance. In comparing averages of biologic series, individual variations within a series may be so large as to cancel any significance. Therefore, Fisher's mathematical formulas and tables (pages 128 and 177), were used to determine the percentage of error in each series or group, and calculate whether the results of comparisons were very significant, slightly significant, or not significant.

The 48 dogs were divided into 8 groups of 6 each. Pressure determinations were made on the first group immediately after operation, and on the remaining groups after 1 hour, 6 hours, 12 hours, 24 hours, 48 hours, 3 days, and 5 days.

RESULTS

Although the procedure used in this experimental study does not reveal any objective information as to the histopathology or bacteriology of the healing process between the bowel and abdominal wall, it does indicate the strength of this

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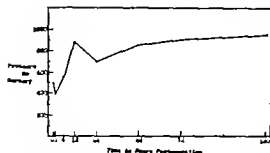
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From the Division of Surgery, Northwestern University Medical School.



Graph. A. Average pressure required to force air between abdominal wall and colostomy loop.

union. Since the tensile strength of inflammatory tissue undoubtedly depends on the fibroblastic elements present, it seems logical to assume a directly proportional relationship between the tensile strength of such a tissue and its rôle as a barrier to the spread of infection. The table shows the average pressure required to force air between the abdominal wall and colostomy loop in each postoperative group. These figures are shown in graph form to facilitate interpretation. After the percentage of error in each group is determined and the significance of comparisons calculated according to Fisher's method, it is found that the colostomy wound after 1 hour is slightly weaker than immediately after operation. Between 1 hour and 12 hours, there occurs a progressive and rapid increase in strength. At 24 hours after operation there is a slightly significant drop in strength as compared with the 12-hour

TABLE I.—PRESSURE REQUIRED TO RUPTURE COLOSTOMY SITE

Time in hrs. after operation	Pressure max. Hg.	Time in hrs. after operation	Pressure avg. Hg.
	400*	24	704
	300	48	845
6	355	72	906
	275	96	950

*Each number is average of determinations on 6 dogs.

determination. There is no significant difference in strength between the determinations taken at 12 hours, 48 hours, 3 days, and 5 days. These results are interpreted as indicating that it is safest to wait at least 12 hours before a loop colostomy is opened, preferably 48 hours.

CONCLUSIONS

1. The strength of a loop colostomy wound is at its weakest point 1 hour after operation.
2. The greatest and most significant increase in the strength of the healing process between a loop colostomy and the abdominal wall occurs between 1 and 12 hours after operation.
3. Between 12 and 24 hours there is a slightly significant drop in strength which is recovered by the 48th hour and is not significantly changed up to and including the 5th day after operation.

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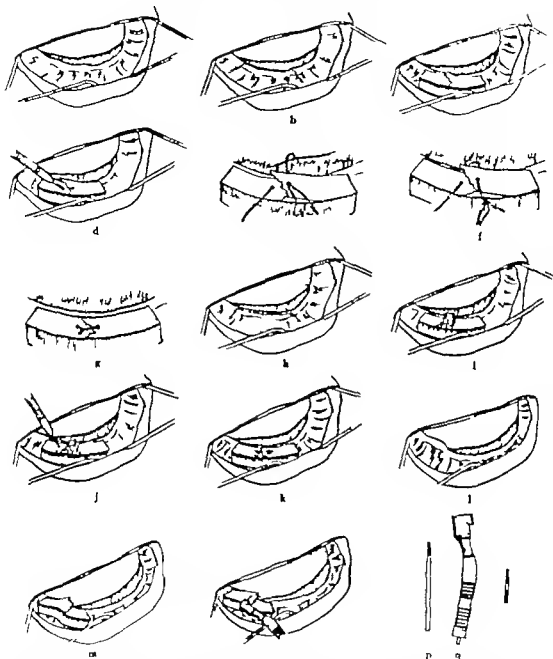


Fig. Operative technique. Alveolar ridge preoperative. b incision by flap. c, flap reflected, reveals g fractured fragments. d, burr holes. e straight bladepiece. f, flap reflected revealing spreading posterior fragment. g, fracture reduced and fixed by craniotom. h, flap returned to position.

and sutured. i, compound tooth. evidence j, multiple burr holes in alveolar segments. k, multiple area placed. l, spreading posterior fragment apparent and guides incision. m, flap reflected revealing spreading posterior fragment. n, contra angle. o, for inaccessible posterior fragments. p, lateral drill for straight bladepiece. q, contra angle round burr for contra angle.



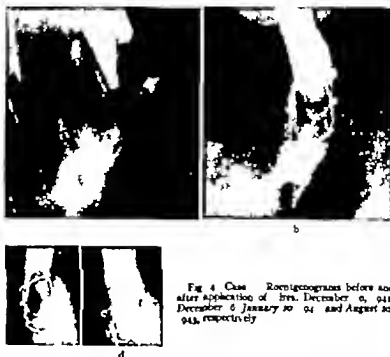


Fig. 4. Case. Roentgenograms before and after application of Irs. December 6, 1941, December 6 January 20, '42 and August 20, 1942, respectively.

dible as carried out with introral approach. The operators were Drs. M. S. Strack and A. E. Strack. Thompson Irs. was used. The constituents of this alloy in its wrought form is nickel 56.3 per cent, cobalt 20.6 per cent, chromium 23.8 per cent, molybdenum 6 per cent.

Although not obvious in the original x-ray view there was comminution. A loose driver of bone 3 centimeters in length was removed. The various fragments were wired together and the mucosa as sutured in place over the wire. Figure 3,b show the wires in position. Hospital course was uneventful as has been the course since then. The Irs. has not been removed. There are no subjective symptoms. The early anasthesia of the mental area has disappeared. Figure 3,c is follow up x-ray view taken November 7, '41. At this time the clinical picture as normal. Figure 3,d is similar view taken April 7, '42. Figure 3,e, view taken November 5, 1941; Figure 3,f, view May 23, 1942. Repair of the fracture and toleration of wire are apparently complete. Figure 3,g is photograph of the patient on May 26, 1942, and Figure 3,h, an introral view at the same time. The contact of the mandibular cortex ensures the fact that contact of the fragments rather than perfect apposition of the parts is necessary in treating fractures of this type.

CASE 2. Patient, W. G. G. 64 years old. Late married. Venotomies entered the hospital for the first time December 7, '41 because of fractured jaw allegedly received in an automobile accident 9 days previously. Treatment had been attempted unsuccessfully elsewhere.

Physical examination showed temperature of 100.6 degrees fah., R respiration, x Multiple urine examinations were essentially negative. Mouth wash culture showed many *Staphylococcus aureus* and *Streptococcus indans*. Admission late count was 14,000, red blood cells 3.06 polymorphonuclears, 79 per cent. Subsequent

white count was 8,000. Histon positive, no adenoma. Wassermann, negative. Subsequent check serums Histon and negative Wassermann.

Right anteroposterior and posteroanterior stereoradiograms of the skull showed badly comminuted fracture of the mandible with several oblique fractures in the region of the angle at the left mandible and transverse fractures on the horizontal ramus of the right mandible across the symphysis also, comminuted fractures of the M of the left maxilla considerable closing of the antrum. The skull as apparently intact. This report as signed by M. C. Sosman.

On December 2, '41 Dr. M. S. Strack, operated. The patient as premedicated on the and 15th milligrams of morphine sulfate. Aertm as administered and the patient as brought to the operating room in the dental chair in the upright position, unconscious. His face and mouth were prepared in the usual way and drapes were then applied. Nasal tubes were passed to assure clear airway. Anesthesia as obtained on the lower right jaw by the injection of 1 per cent procaine buffered containing 3 drops of adrenalin chloride to 30 cubic centimeters. The injection as made at the right mandibular foramen.

It was noted at this time that there was marked overriding of the bony fragments on the lower right side and that the mucous membrane as entirely healed at the site of the original perforation. When all as in mind new, heavy towel clip was fastened to the anterior segment. A incision as made along the upper border of the right jaw and the soft tissue on the buccal and lingual aspect as dissected. Good exposure of the fractured area was obtained and the fibrous union as broken by means of blunt dissection. By means of dental burr two holes were drilled in the mental and M were drilled into the distal segments. The segments were then approximated and immobilized

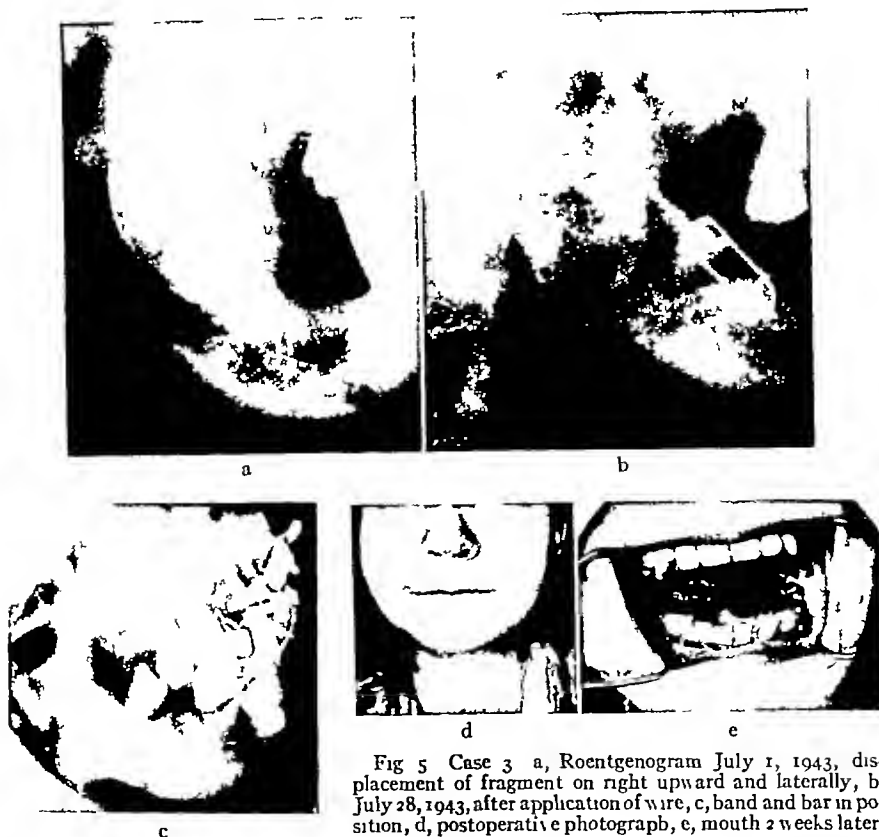


Fig 5 Case 3 a, Roentgenogram July 1, 1943, displacement of fragment on right upward and laterally, b, July 28, 1943, after application of wire, c, band and bar in position, d, postoperative photograph, e, mouth 2 weeks later

with two separate pieces of ticonium wire. The excess wire was cut away and the free ends were tucked in toward the bone. The soft tissues were then approximated and held in position with black silk sutures. The result at this time appeared quite satisfactory. At the beginning of the operation the patient's blood pressure rose to over 210, and remained unevenly elevated until the close of the operation. On several occasions the patient became cyanotic. This was immediately relieved by the extension of the tongue and of the anterior segment of the jaw. There was no unusual bleeding at the close of the operation, and the patient left the operating room in good condition. Recovery was uneventful. The patient's progress was good and he was discharged as improved from the hospital on the 8th postoperative day. Figures 4,a,b,c, and d are preoperative and postoperative roentgenographic views.

CASE 3 Patient F W, 36 year old housewife, entered Peter Bent Brigham Hospital on surgical derision for first time. She was suffering from a swollen painful jaw. She was knocked to the ground 4 days before admission and the day before the right lower molar was extracted following which extraction she had severe pain, and was unable to sleep and eat. Her temperature was 101 degrees, pulse, 96, respiration, 20. Hinton was negative. Urine examination was essentially negative. Red count was within normal limits, white count 10,600 on admission, falling to 6,300 on discharge. On admission differential was 82 polymorphonuclears. Fasting blood sugar was 97 milligrams per cent, diastase level, 12.8 and 18.9 milligrams per cent.

X ray report on July 1, 1943 revealed bilateral fractures of mandible transversely through the canine region on the left, obliquely through the molar region on the right. The posterior fragment on the right was displaced upward and laterally (Fig 5,a). The fragments on the left were in excellent position. July 2, 1943, stereoroentgenograms of the chest showed a bronchopneumonic patch at the left base anteriorly just above the apex of the heart. The right lung was quite clear. The heart was not displaced. No foreign body was demonstrable (M C Sosman).

On July 9, 1943, irrigation and drainage of the left submental area, planned to be done with electrosurgical scalpel, was done with knife when tube blew on direct current. Discharge was good and area was obviously connected with the mandibular left cuspid in the fracture site. This tooth is to be extracted at the time of wiring which is being delayed due to patient's pneumonia. Ethyl chloride was used as spray for anesthesia. The patient is obvious candidate for general anesthesia at time of wiring.

On July 20, 1943, under ether anesthesia, the badly displaced edentulous fragments of the right side of the fractured mandible were laid bare by an incision along the alveolar crest. Burr holes were made on either side of the fracture. Fibrous tissue was removed from the fracture site. Tantalum (element Ta) wire 020 gauge was passed through the holes, and the fracture was reduced. Mandibular left cuspid was then extracted and a Kazanjian type band and bar were placed with the band on the lower left second bicuspid. Tantalum wire buttons made by twisting strands



Fig. 6. Case 4. (a) and (c), Operative views. (b), wires in place; (d), after reduction of fracture; (e), postoperative view; (f) and (g), 7th postoperative day.

of wires on themselves, are placed right and left. The wire on the right side, as then twisted tight and cut short (Fig. 5,b). This procedure, as left to be done, is this time to old manipulation during band and bar placement (Fig. 5,c). Flaps were then returned to position and sutured. Elastic are placed. Patient left operating room in good condition. Figure 5,d is postoperative photograph.

Patient developed marked edema of the right side of the face, which subsided promptly and she was discharged from the hospital on the 8th postoperative day. Figure 5,e is photograph, weeks later.

CASE. Patient O.S.D. 39 year old widow, as admitted to this Hospital October 9, 1943, from the Fairview Hospital, where she had regressed consciousness after the automobile she was driving collided with hydrant.

On admission the red blood cells and hemoglobin were normal, white blood cells numbered 3,000. Differential count was 8 per cent polymorphonuclears, 11 8 per cent lymphocytes, smear was normal, urine normal, total protein, normal, lumbar puncture showed 68 red blood cells, 66 lymphocytes.

X-ray report (Figs. 6,a,c) October 9, 1943, was as follows. Films of the right mandible showed complete transverse comminuted fracture through the mandible just above the angle. There was overlapping of the fragments, the proximal fragment being anterior to and above the ramus. Anteroposterior view showed comminution with loose fragment from the lateral cortex. The mandible elsewhere appeared normal. There was no fracture of the

condyloid process or neck on the left. The skull appeared normal with no evidence of fracture elsewhere. (M. C. Sossman)

On Oct. 4, 1943, the patient, as premedicated with tropine sulfate 0.005 gram and morphine sulfate 0.03 gram, later before being brought to the operating room, here the usual drapes are applied with patient reclining in the dental chair. The right inferior alveolar nerve was blocked with 1 per cent novocaine infiltration for anesthesia of the long buccal nerve, as also carried out. The throat as packed off and the mouth bandaged as fixation, as made along the crest of the alveolus of the right mandibular socket area extending back into the retro-molar area over the obviously displaced fractured fragments which are readily revealed beneath the mucoperiosteum as reflected. There is little evidence of any fibrosis. By means of straight bandpawes and bivalve drill, bony holes were made in either side of the fracture in Tantalum Iro No. 20, as passed through these holes, the fracture, as reduced and held in this position the wire as twisted up tight (Fig. 6,b). Flaps are returned in place sutured with silk (Fig. 6,d). Pressure bandage as applied to keep the edema down. Patient returned operating room off and left operating room in good condition.

The patient's progress as good and he as discharged from the Hospital on the 5th postoperative day. Figure 6,e is postoperative view and Figure 6,f and g are photographs on the 7th postoperative day.

SUMMARY

Direct fixation is the method of choice in fractured edentulous mandibles in cases in which displaced fragments are present and accessible. Wiring of this type obviates the necessity for skeletal fixation in most instances of mandibular fracture without tissue loss. In view of the known toleration of various inert metals, it is advisable that wires made of these inert substances, such as steelium and tantalum, be used whenever direct fixation of the fractures is indicated. When so used it can be done with assurance that these wires may be placed without the necessity of planning their removal, should it be so desired.

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THE PLACEMENT OF INCISIONS IN THE NECK

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OLD, presumably self-evident, truths must be retold occasionally to insure that they be not forgotten. In a recent tour of surgical clinics, I was startled to see at two leading centers transgression of an old axiom that incisions in the neck

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shall not cross the normal creases of the skin. Although the once standard incisions for thyroidectomy paralleled the inner border of the sternomastoid muscle on both sides of the neck, no present-day surgeon would view them with anything but abhorrence. Similarly, vertical incisions for the excision of branchial cysts, or for the opening of cervical abscesses, should be

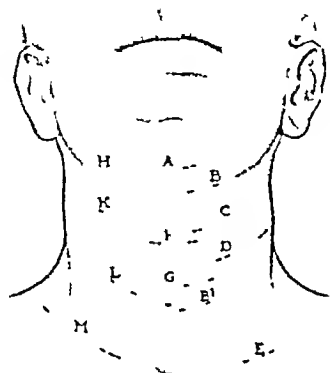


Fig 1

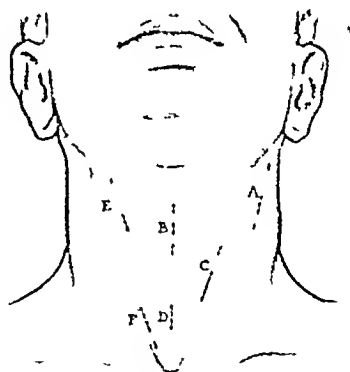


Fig 2

Fig. 1 Proper placement of incisions in the neck paralleling the normal lines and folds of the skin. *A*, for drainage of submental abscess. *B*, for excision of congenital sinus partially mobilized through incision *B*. *B'* for mobilization of sinus tract presenting at *B'* but penetrating pharynx at *B*. *C*, for excision of carotid tumor or branchial cyst. *D* for diverticulum of the esophagus. *E*, for scalenotomy or phrenic interruption. *F*, for cricothyrotomy. *G*, for tracheotomy. *H*, for drainage of cervical abscess at angle of the jaw. *I*, for exposure of internal or external carotid. *L*, for exposure of common carotid. *M*, for exposure of brachial plexus.

Fig. 2 Placement of incisions as recommended in a recently published textbook (1943) illustrating modern surgical technique, all of which transgress the rule not to cross creases of the skin in the neck. *A*, for excision of a carotid tumor. *B*, for cricothyrotomy. *C*, for lateral esophagotomy. *D*, for tracheotomy. *E*, for exposure of the external carotid artery. *F*, for exposure of the common carotid artery.

viewed with an instinctive version by all surgeons.

An incision that crosses the normal lines of the skin in a region characterized by constant motion as in the neck will almost invariably produce a thick unsightly scar that is likely to become more prominent as time passes and that may even assume the character of a keloid. The placement of incisions in the neck, therefore, is particularly important in women, who may suffer untold mental anguish from badly placed incisions that produce keloidal scars in conspicuous and constantly self-observed areas.

In reviewing special articles and textbooks (Fig. 2) on operations for parotid tumors, for esophageal diverticula, for ligation of the carotid vessels, for laryngectomy, it is obvious that many surgeons though aware of the necessity of employing an incision for thyroidectomy that parallels the normal folds of the skin do not apply this knowledge in their surgical approach to other structures in the cervical region. The point need not be belabored further. Every effort should be made to place an incision for any of the operative procedures named in a crease of the skin, or paralleling a crease if necessity demands that the incision be placed where no crease exists. However we have no hesitancy—except in draining abscesses—to reflect skin flaps either upward or downward for one or two centimeters more if thereby the incision can be made to coincide with a normal crease in the skin demonstrable before operation.

In the removal of congenital sinus which presents in the neck above the clavicle and extends upward to penetrate the pharynx in the region of the tonsil, adequate exposure is easily obtained through two transverse incisions paralleling the

skin creases (Fig. 1 *B* and *B'*) and these should be used in preference to a vertical incision paralleling and following the sinus tract as is so often advised. A temporary tracheostomy can be performed through a transverse incision (Fig. *G*) with minimal residual scarring, whereas the scar of a vertical incision may be an aggravation forever to its possessor. The ligation of the carotid artery, whether common or internal can be performed as readily through skin-crease incisions (Fig. 1 *A* and *L*) as through incisions paralleling the sternomastoid muscle and the scars after several months are almost nondetectable. After the skin flaps are reflected the muscle is retracted laterally and not divided. Similar branchial cysts, esophageal diverticula, carotid body tumors (Fig. 1 *C* and *D*) may be removed through crease-parallel incisions permitting wide reflection of skin flaps and retraction of the muscle for adequate exposure. Incisions for the draining of cervical abscesses, wherever located will heal with minimum scarring if placed parallel to the normal lines of the skin (Fig. 1 and *II*).

Careful closure of the platysm muscle with interrupted fine silk or cotton sutures is a necessary part of closing any incision in the neck. Sutures closing the skin should be removed in 48 hours to avoid producing transverse scars and permanent cross-hatching at the site of each suture.

These suggestions are made only, as reaffirmations of the teachings of painstaking surgeons of the past, teachings which long since should have become universally recognized as fundamental in the art of surgery. The reproaches of sensitive women should be avoided by the surgeon called upon to perform an operation in an area so laterminally visible to her.

VENTRAL HERNIA DUE TO NORMAL BANDING OF THE ABDOMINAL MUSCLES

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THE term "ventral hernia" is applied to all protrusions of abdominal content through the anterolateral wall other than through the inguinal or umbilical orifices. The traumatic defects, including those which follow surgical operations, will not be considered in this discussion because they are not directly based upon anatomical predispositions. The spontaneous hernias, however, are due to a variety of structural deficiencies in the musculoponeurotic layers of the abdominal wall, most of which have not been adequately explained. Included in this group are hernias of the midline (hernias of the linea alba or epigastric hernias), and the lateral ventral hernias comprising the lumbar group, those of the semilunar line, and those due to "banding" of the fibers of the internal oblique and transverse abdominal muscles. This study is particularly concerned with the last named variety, and with the anatomical peculiarities which predispose to them.

Earlier articles by the authors have presented the special anatomical features of the lower inguinal and funicular portions of the abdominal layers (especially, Morgan and Anson, 1942; Morgan, Anson, and McVay, 1942); the present paper is concerned with the nature of the same layers in the territory just superior to that in which direct and indirect hernias occur. In this stripe between the level of the so called aponeurotic inguinal fold and umbilicus, the internal oblique layer is subject to striking departures from the accepted form, while the external oblique and the transverse abdominal exhibit less profound aberrancies.

ANATOMICAL STUDIES

Material and methods. In a general study of inguinal anatomy, body-halves totaling 500 have been examined to date. The statistical results of this investigation will be presented later¹; interest

¹A contribution from the Department of Surgery and the Department of Anatomy, Northwestern University Medical School Chicago III. The opinions or assertions contained herein are the private ones of the writers and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large; similarly they are not official for the Army.

²Article in preparation by E. H. Morgan, B. J. Anson, C. B. McVay and R. R. Wright.

now centers in the occurrence of aponeurotic muscular arrangements that predispose to weakness against parietal herniation. Appropriate clinical aspects will be discussed, based upon experience in the management of such hernias.

In studying inguinal anatomy in the 250 consecutive adult specimens, male and female, the outstanding features of each of the three anterolateral musculoponeurotic layers were recorded in full sized measured sketches. These permanent records were employed as material for cataloging "types" of inguinal parietes and for recording incidence of certain selected elements. For the present article data on character of the internal oblique were employed, 3 particularly favorable specimens were used for illustrations (Figs. 1 to 3).

Observations and discussion. *External oblique.* The chief respect in which this outermost of the muscle layers exhibits variability is in the length and width of the triangular hiatus between the crura of the subcutaneous inguinal ring (Fig. 3b, internal view of cleft). This may extend, at its lateral or apical part, to the anterior superior iliac spine, or it may reach a point only midway between the latter and the pubic tubercle. As the length of the fault increases,avity of the intercrural wall of fascia, of course, becomes greater. But whether the interval be short or long, there exists potentially a large subaponeurotic space into which a herniating mass may press. This areolar plane, or "space," extends almost to the midline of the abdomen, since the inguinal union of aponeuroses of external and internal oblique muscles takes place not along the lateral border of the rectus muscle but in virtually a median position (Figs. 1 and 2). This space could be occupied by a hernia of parietal character.

Internal oblique and transverse abdominal. The internal oblique layer is figured in all standard textbooks of gross and of applied anatomy as a layer of simple uniformity. Its muscular portion is pictured as being a stratum of evenly distributed fascicles except where distally these fibers may be carried downward upon the spermatic cords (Figs. 1, b and 1, c). But actually such an arrangement fails to appear in many specimens. The in-

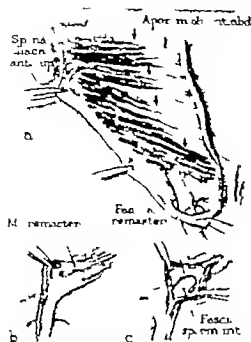


Fig. 1. Lateral part of internal oblique muscle. Specimen of well developed adult white male. a, Medially the external oblique aponeurosis has been cut along the line of contractility with that of the internal oblique and, inferiorly near the inguinal ligament, sparing medially the subcutaneous inguinal comp. The bands of the internal oblique are indicated by arrow a. b The aponeurosis of the external oblique muscle (opposite side of same subject) has been incised through the superior crest of the ring and turned inferiorly to expose the internal oblique muscle. The muscle sends few fascicles downward upon the cord, the remainder of the cremasteric investment being fascial. c, The cremasteric fascia has been incised and the margins have been drawn aside to expose the internal spermatic fascial layer of the cord.

tribute to the formation of the rectus sheath (Fig. 1 a, Fig. 2). The other bands are usually shorter terminating along a vertical line which is lateral to the outer margin of the rectus muscle. The bands generally are arranged like the blades of a slightly opened fan with the interspaces increasing as the medial extremities are approached. The internal oblique layer in the female specimen is likewise banded (Fig. 2 arrows) since their course is more oblique than that of the bands which they overlie. The bands are separable from subjacent tissue at the point where they fuse with aponeurosis of the external oblique.

In the authors' study of 500 body halves, defects of this nature, which conceivably could permit of parietal herniation were found in 100 (18%). These deficiencies took the form of slit like gaps between divergent bundles of fibers. The investing fascial layers of the internal oblique bridged the defects the fascia often contained small masses of fat. Sometimes herniations of fatty preperitoneal tissue passed through the transversus layer to occupy the defects in the internal oblique stratum (Fig. 3 a, labelled). The width of these defects varied between 0 and 5 centimeters. In some specimens more than one musculoponeurotic deficiency appeared (Table I).

inferior fascicles may lie cranial to the level of the inguinal canal, the cremasteric or fascicular layer then being wholly fascial (Fig. 1 a). Furthermore the main, or parietal, part of the stratum may consist of separate musculoponeurotic bands held together by the external and internal investing fascial layers.

Three selected adult specimens will serve to demonstrate these features. Two are well developed males (Figs. 1 a to 1 c and Fig. 3), the other an equally favorable female cadaver (Fig. 2). The internal oblique muscles in the male specimens are strikingly banded (Fig. 1 a at arrows Fig. 3 a at boundaries of space marked by asterisk). The lowermost is likely to remain muscular to the point of fusion of the poneuroses of the external and internal oblique muscles where these layers con-

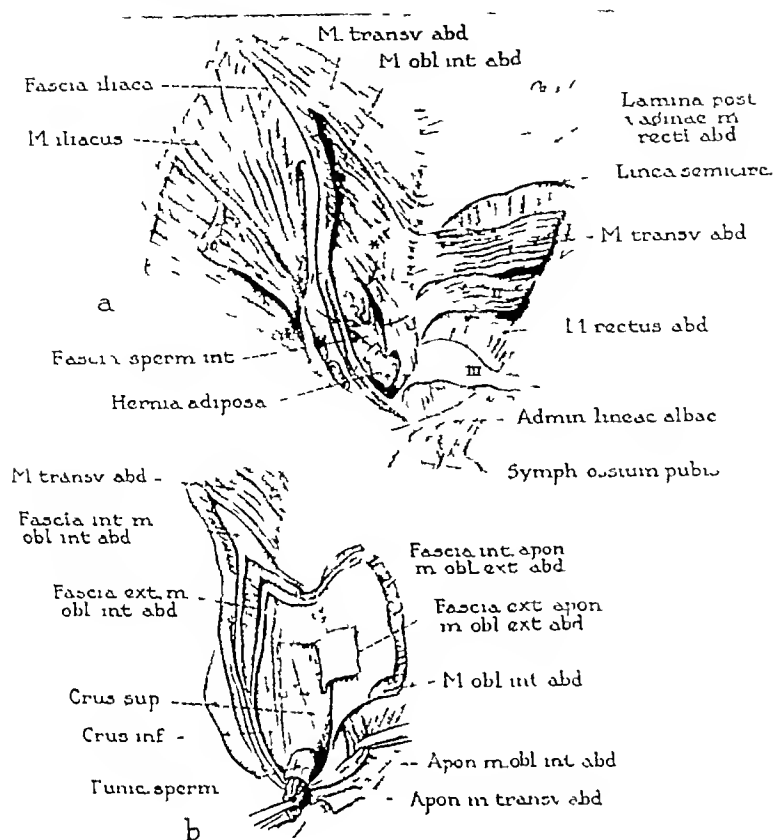


Fig 3 Posterior aspect of inguinal layers a, internal oblique. A portion of the transversus abdominis has been turned medialward along the line of fusion with the internal oblique. The upper part (slips I and II) is musculoaponeurotic, the lower part (slip III) is entirely fascial, and forms the thin posterior wall of the inguinal canal. The internal oblique is likewise fascial in its lower part (marked by arrows) and is weakened by fatty tissue collected in the area above the cremaster (at *). The hiatus for a hernia adiposa lies just medial to the ring. b, Transverse abdominal muscle (same specimen). The internal oblique has been reflected in the region of the inguinal canal, but the tubular cremasteric prolongation is intact around the spermatic cord. The external oblique aponeurosis is exposed in the area of the intercrural defect in the aponeurosis. The thin external and internal layers of investing fascia are demonstrated by reflecting a small area of the latter. (From Morgan and Anson, 1942)

The inguinohypogastric portion of the transversus was studied in 165 body halves. Musculoaponeurotic defects appeared in 27 specimens. In 19 instances there was but one defect, and in 8 specimens there were multiple deficiencies. Both in form and in relative size these musculoaponeurotic defects resembled those described for the internal oblique stratum.

For the occurrence of elongate defects in both musculoaponeurotic strata in individual specimens, and for the relations of these defects to each other, 100 body halves were examined (Ta-

ble II). They were found in one or in both layers in 45 specimens. In 25 specimens one or more defects occurred in the internal oblique stratum alone, in 10 specimens there were one or more gaps in the transversus layer, and in 10 specimens there were defects in both strata. Of this last group a total of 6 specimens possessed superimposed defects. In the remaining 4 the defect in the transversus stratum lay cranial in position to the gap in the internal oblique. It is, of course, in the specimens in which superimposed defects occur (6 in 100 studied) that parietal herniation

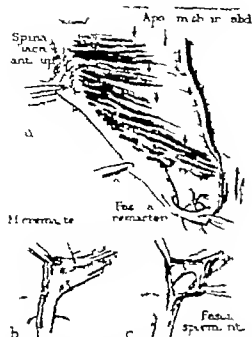


Fig. 1. Inguinal part of internal oblique muscle. Specimen of well developed adult white male. (a) Medially the external oblique aponeurosis has been cut along the line of continuity with that of the internal oblique and, inferiorly near the inguinal ring, opening medially the subcutaneous inguinal ring. The bands of the internal oblique are indicated by arrows. (b) The aponeurosis of the external oblique muscle (opposite side of same subject) has been incised through the superior rim of the ring and turned inferiorly to expose the internal oblique muscle. The muscle sends few fascicles downward upon the cord, the remainder of the cremasteric investment being fascial. (c) The cremasteric fascia has been incised and the margins have been drawn aside to expose the internal spermatic fascial layer of the cord.

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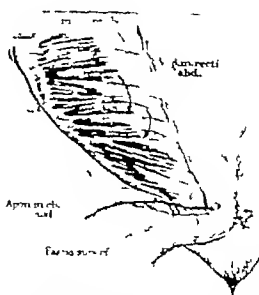


Fig. 2. Lateral part of internal oblique muscle. Specimen of well developed adult white female. The external oblique has been incised and turned aside as in Figure 1. The muscle is very definitely banded (arrows pass beneath two prominent bands).

tribute to the formation of the rectus sheath (Fig. 3, Fig. 4).

The other bands are usually shorter terminating along a vertical line which is lateral to the outer margin of the rectus muscle. The bands generally are arranged like the blades of a slightly opened fan, with the interspaces increasing as the medial extremities are approached. The internal oblique layer in the female specimen is likewise banded. Two of these stand out prominently (Fig. 3, arrows) since their course is more oblique than that of the bands which they overlie. The bands are separable from subjacent those to the point where they fuse with ponsuroses of the external oblique.

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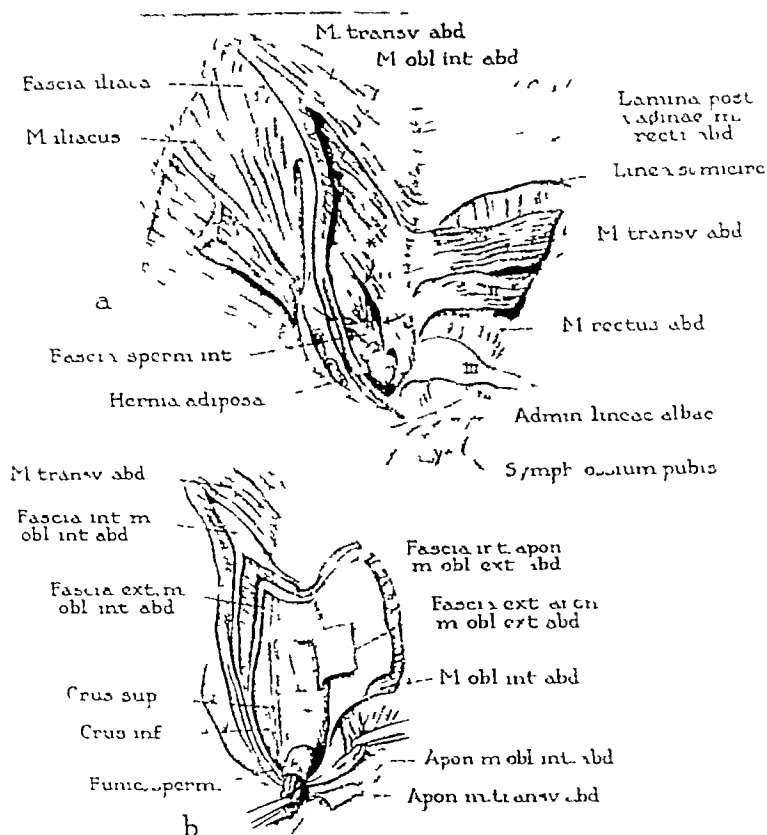


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TABLE I —INCIDENCE OF MUSCULOAPONEUROTIC DEFECTS IN INTERNAL OBLIQUE (50 Body Halves)

Description	Number	Percentage
With defect	74	48
With defect	3	6.4
With 3 defects	3	6
Total defects	80	8

would be most likely to occur. In one such specimen a hernia adiposa from the preperitoneal layer passed through both the internal oblique and the transverse abdominal.

CLINICAL APPLICATIONS

The anatomical observations described shed important and hitherto unrecognized light upon the genesis and pathology of spontaneous lateral ventral hernias exclusive of the lumbar group. These are usually described as hernias of the *linea semilunaris* (Spigel). This line is a curved depression extending from the tip of the ninth rib to the pubis, marking the outer edge of the rectus sheath. There are no structural weaknesses specifically peculiar to this anatomical landmark. Quite to the contrary it represents the line of fusion of the aponeuroses of the internal oblique and transversus abdominis muscles and is, consequently, an area of strength rather than of weakness. There is, therefore, no reason to anticipate the frequent occurrence of hernias along this line.

The *linea semilunaris* is defined somewhat differently in discussion of semilunar line hernias. In recent presentation of the subject River (194) states "the *linea semilunaris* is the line of transition between the muscle bundles and aponeurosis of the transversus abdominis muscle. The anatomical studies of Anson and his associates have demonstrated a very wide variation in the relative amounts of muscle and aponeurosis in the transversus layer and the line of their transition in no way coincides with the anatomically defined semilunar line. The area described does coincide, however, with the zone under discussion in this study in which defects occur due to handling of the muscle fibers of the internal oblique and transverse abdominal muscles.

Most of the hernias of the *linea semilunaris* are further described as occurring at or below the level of the semilunar fold of Douglas. This coincides with the distribution of defects in the muscular layers described herein and would suggest that they fall into two categories. Those that appear inferior to the lowermost fibers of the internal oblique would fulfill the requirements of diverticular direct hernias, those emerging above this

TABLE II —INCIDENCE OF DEFECTS IN INTERNAL OBLIQUE AND TRANSVERSE ABDOMINAL ALONE OR TOGETHER AND SUPRIMPOSED (100 Body Halves)

Description	Number	Percentage
Defect in one or both layers	41	41
Defect in internal oblique alone	5	5
Defect in transverse abdominal alone		
Defects in both layers		
1) Supraposed defects	6	
2) Defect in transversus cranial to that in internal oblique	4	
Total defects	50	

level would conform with the type here discussed. I.e., herniation between banded or segmented muscle fibers of the internal oblique and transverse layers.

In the genesis of spontaneous lateral ventral hernias, in addition to the congenital anatomical predispositions, factors which increase abdominal tension are contributory. Prominent among these are obesity, pregnancies, ascites, chronic cough, and severe muscular effort. These hernias are not infrequently associated with other types of abdominal hernia.

The hernial ring in such cases is usually a sharply defined defect in the transversus aponeurosis, which rarely exceeds a centimeter in diameter. The sac is often preceded by a lipomatous mass of preperitoneal fatty tissue. The hernia is frequently lateral parietal, penetrating the transverse and internal oblique layers, and spreading out between the latter and the intact overlying aponeurosis of the external oblique. The contents usually consist of omentum and small bowel and incarceration or strangulation are not common.

Spontaneous lateral ventral hernias may cause no symptoms. Some, however, are accompanied by distress which may be mild or severe and which is aggravated by standing or straining, and relieved by reduction of the hernia. The mass may not be palpable if it is small and interparietal in position. Although swelling or resistance is usually discernible in incarcerated or strangulated hernias, tenderness over the mass or over the defect in reducible hernias is considered a characteristic finding.

The only available treatment for lateral ventral hernia is surgical repair. The operation requires first the exposure of the mass. Since the position is often interparietal this frequently necessitates division of the aponeuroses of the external oblique. The subjacent sac and its attached lipomatous mass of preperitoneal fat must then be dissected free from the surrounding muscular and fascial

structures down to the level of the preperitoneal areolar layer. The sac should be opened and its contents reduced. Adherent omentum may have to be resected between ligatures. The sac is then closed by transfixion or suture, and its stump returned to the preperitoneal space.

Closure of the hernial defect is effected by defining the hiatuses in the transverse and internal oblique layers and obliterating them by suture. As has been stated, the ring is small, and usually no difficulty is encountered in approximating the fascial edges. In rare instances of large hernias and poorly developed tissues, fascial sutures or transplants of fascia might conceivably be of value. The apposition of a firm reunited external oblique aponeurosis usually provides sufficient reinforcement to obviate the need for further operative manipulation.

Personal observations In addition to the potential and actual hernias through defects due to banding of the transverse abdominal and internal oblique muscles which were found in the anatomical studies described herein, we have encountered 3 such cases at the operating table during the past few years. The first 2 occurred before the anatomical basis for them had been worked out. The most recent one was made clear by these studies, and careful inspection proved it to coincide in every respect with the anatomical findings herein presented in detail (Fig 4).

The patient in this case was a young man who entered the hospital because of bilateral direct hernia. The internal oblique muscle was very poorly developed, its lower fibers ending at the level of the internal rings. On the left side a wide gap was seen between bands of muscle fibers of the internal oblique, about 1 1/2 inches (4 cm) above the internal ring, through which protruded a fatty mass. Exploration disclosed a long pedunculated preperitoneal lipoma which preceded a peritoneal hernial sac. The hernia emerged through a sharply defined ring in the transversalis fascia passed through a defect between bands of muscle fibers of the internal oblique, and spread itself interparietally between the internal oblique and the intact external oblique aponeurosis.

The sac was opened and inspected. There were no adherent contents. It was then dissected free from the internal oblique and transversalis layers and closed by transfixion at its base, with a fine silk suture. The sac and lipoma were excised and the stump reduced into the preperitoneal space. The hiatus in the transversalis fascia was closed by silk suture, and the gaping fibers of internal oblique approximated with interrupted sutures. The direct hernia was repaired by the method described by one of us (Zimmerman, 1938) and the external oblique aponeurosis was closed over both the inguinal and ventral hernias. The patient made a totally uneventful recovery, and when last seen was free from recurrence of any of the hernias.

The other 2 cases observed were in women, both of middle age and both obese and multiparous. Operation was undertaken because of poorly de-

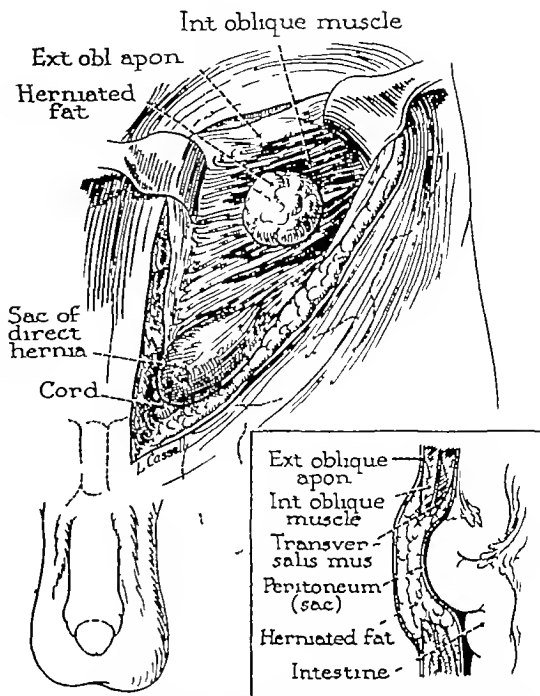


Fig 4 Surgical case, from drawing prepared at operation. Inset, section showing relation of intestine and of subperitoneal fat to the muscular margins of the parietal defect.

fined swellings in the lower abdomen, which were associated with discomfort on exertion and tenderness to pressure. In both, spontaneous ventral hernias of this type were found emerging through the internal oblique triangle and lateral to the linea semilunaris. The bulk of the mass was made up of extraperitoneal adipose tissue.

It is entirely probable that spontaneous ventral hernias of this type are far more prevalent than the very small number of reported cases would imply. Our own experience, both in the anatomical laboratory and the operating room, indicates that they are not rare. It is hoped that bringing them to the attention of surgeons and establishing their pathogenesis will result in a more frequent recognition and reporting of this type of hernia.

SUMMARY

Far from being a series of layers whose features can be presented adequately and correctly in a conventionalized account, the anterolateral abdominal muscles display such marked departures from an anatomic norm that consideration of at least the extreme variants is essential to careful diagnosis of hernia and to rational and lasting repair.

Of the three abdominal muscular layers, the external is the least variable in the inguinal area it is quite uniformly aponeurotic. But the intermediate and deep layers, namely the internal oblique and the transverse abdominal are frequently variable they are often represented only by fascia in their inferomedial extent, or disposed in the form of oblique musculoaponeurotic bands bound together solely by fascia. In the latter instance narrow segmental stripes of fascia would intervene between wider and heavier ribbons of muscle or of aponeurosis, their weakness offering parietal exit to a adipose mass in the preperitoneal layer or to omentum or intestine. Where areas of local weakness were superimposed, extrusion would be facil-

itated. The occurrence of ventral hernia is explainable on these fundamental grounds.

Cases are described in which spontaneous lateral ventral hernias occurred due to such banding of the fibers of the internal oblique and transversus abdominis muscles. Their origins and structural characteristics are fully explained by the anatomical studies herein presented.

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THE CORRECTION OF ABNORMALLY PROMINENT EARS

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THE external ear has certain definite characteristics of contour which are accepted as normal. These may vary within rather wide limits of detail, but on the whole normal ears have certain ridges, depressions, and positions in common. The normal ear may be large or small, its convolutions finely or bluntly chiseled, but on close inspection the configurations are found to follow a definite plan. Moreover, the position of the normal ear on the head is constant within fairly narrow limits. To be normal, the configurations of the two ears must be the same, but of far more importance, the position on the head must be such that they are symmetrical.

The normal relation of the ear to the head is usually expressed by stating that the ear rests on the head at an angle of about 30 degrees. From the reconstructive viewpoint more information is conveyed and better appreciation of the criteria to be fulfilled is indicated if one considers the external ear as two separate structures, the conchal portion, and the scapha. The dividing line between these two portions is the antihelix.

If one views the normal ear from above, it is noted that the conchal portion forms an angle of approximately 90 degrees with the head, and the scapha in turn forms another angle of about 90 degrees with this (Fig 1, a). The rim of the ear then curves outward as the helix. The conchal-head angle varies very little. The angle between the scapha and the concha may vary as much as 10 to 15 degrees to either side of a right angle and still not appear abnormal.

From in front the posterior wall of the conchal hollow, the ridge of the antihelix, and the helix are all seen. The helical rim is seen as an edge just visible beyond and behind the antihelix (Fig 1, c). If one measures the angle formed by the plane of the ear, as seen from the front, and the side of the head, it varies as does the angle formed between the concha and scapha. It may be the angle of 30 degrees frequently mentioned but in the normal ear is usually less.

From the direct lateral view of a normal ear the entire configuration is visible. The relationship of 90 degrees between the concha and the scapha allows one to see the entire ear including the an-

terior and superior crura of the antihelix and the triangular fossa (Fig 2). The lateral view of the ear also shows that the ear has a definite positional relationship to the head as regards its long axis. If the chin is not receding, it is found that the angle formed between the long axis of the ear and the vertical plane of the face is almost a constant of 20 degrees (Fig 3).

Abnormally prominent ears differ in that from front and rear views one's attention is attracted to the wing-like projection. If the structure of these ears is analyzed, it is found that the difference is almost purely one of the angular relationship of the scapha to the concha. In extremely prominent ears the antihelical ridge may be almost entirely absent and the angle between the concha and scapha as great as 150 to 160 degrees (Fig 1, b). The conchal relationship to the head is normal. The angle remains about 90 degrees. However, these ears often appear large and this may be due to an actual increase in length of the portion of concha which extends outward from the head to the antihelix.

From this description it can be seen that we disagree with the oft repeated statement that abnormal prominence of the ear is due to an "unusually wide angle between the concha and the mastoid process" (6). In our opinion, the abnormal position is due to an increase in the right angle normally present at the antihelix.

INDICATIONS FOR CORRECTION

The abnormally prominent ear is most objectionable in men. Women can usually cover the projecting ear with appropriate hairdress. The position of the external ear does not affect hearing to an appreciable extent, so that the indication for operation is usually psychologic. Hence correction of the projection is often carried out in children before they reach school age to avoid the problems which arise from ridicule by their schoolmates. Operation at an early age does not interfere with normal growth of the ear.

In addition to the prevention of psychologic handicaps in children there are a certain number of adults who ask to have abnormal projection of the ears corrected for practical reasons. This group includes women whose hair has become so thin that the ears can no longer be covered satisfactorily and men who for one reason or another

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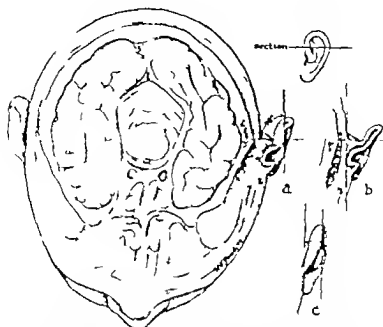


Fig. 1. a, Drawing of an actual cross section of the head from the anatomical laboratory. This section shows the usual angular relationship of about 90 degrees between the head, concha, and scapha. b, Shows an increase of conchal scaphal angle which could still be the normal limit. c, Shows normal ear from directly in front. Not that the head can be visible.

believe that their noticeable appearance is an economic handicap.

EVOLUTION OF OPERATIVE CORRECTION

We have never seen any appreciable correction obtained by mechanical means. Most children brought by their parents for correction of abnormal protrusion of the ears have had their ears strapped against the head for varying periods

as infants, or have worn tight fitting caps at night. Although the position can be corrected by these restraints the ear immediately returns to its former position on removal of the restraint due to the springlike action of the abnormally angled cartilage.

Numerous surgical methods for restoring the widely protruding ear to more normal position have been described. Most of these are of interest only from the historical standpoint, but do show the gradual development of the operation.

The simplest and probably earliest surgical attempt at correction was by the removal of an ellipse of skin from the cephaloauricular angle so that one-half of the skin raised was from the mastoid area and the other half from the ear. The perichondrium of the exposed concha, as this approximated the mastoid galea when the skin edges were sutured. This operation was rarely permanently successful. The spring of the cartilage gradually pulled the ear back to the original position. Moreover the removal of an ellipse of skin from the cephaloauricular angle obliterates the normal sulcus to certain extent. This operation might be successful in young children when the auricular cartilage is very soft and only slight

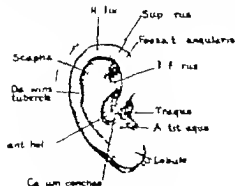


Fig. 2. Drawing of normal ear. The configuration must follow this pattern to be acceptable.

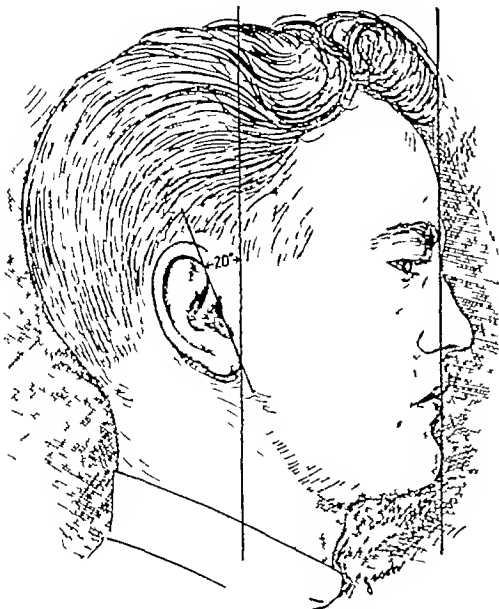


Fig 3 The ear forms an angle of 20 degrees with the vertical plane of the face. This relationship is almost absolutely constant.

ly deformed. Even then the permanency of the result is questionable. This operation is rarely used at present.

The next logical evolution in operative attempts at correction was the addition of the excision of an ellipse of conchal cartilage corresponding in size to the skin removed. The strip of cartilage was removed near or at the head-ear junction so that the ear as a whole was rotated backward into closer approximation with the head. This operation was described by Morestin in 1903. This operation permanently reduces the appearance of abnormal prominence of the ear when viewed from front and back, although the ear still has abnormal configurations (Fig 10). It is most successful when the increase in the antihelix angle is minimal. At best it is a compromise correction. The ear is brought closer to the head but the scapha still projects abnormally due to the uncorrected increased angle at the antihelix line. In addition it is objectionable because the excess anterior skin left in the conchal hollow forms a noticeable abnormal ridge, and at times one can see a sharp line in the concha due to the cut edge of the conchal cartilage underneath the skin.

The numerous operations devised to attach the ear to the head without removal of cartilage are evidence that the Morestin procedure was not entirely fault free. Among these are the insertion

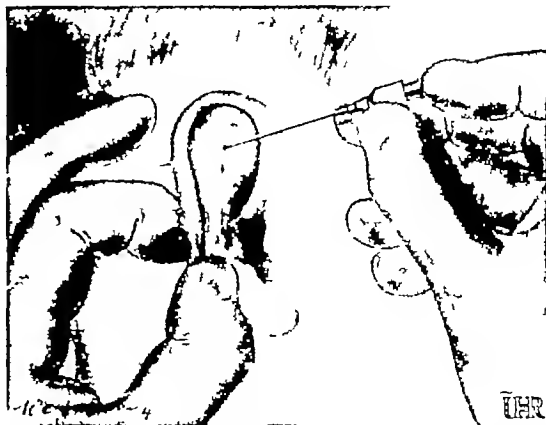


Fig 4 The method described by Davis of marking the line of the antihelix with puncture by a hypodermic needle dipped in methylene blue. In Davis's illustrations the superior crus only is marked. It will be noted that the marking extends along both the superior and inferior crus to outline the triangular fossa.

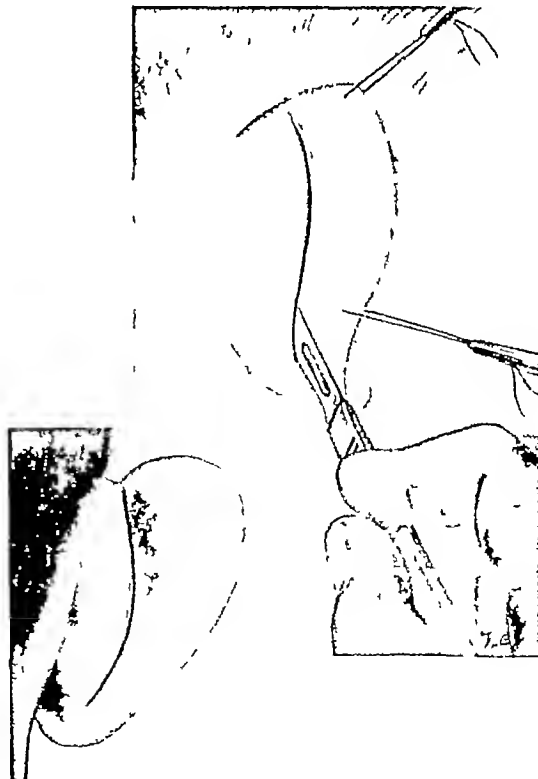


Fig 5 The operative approach is on the posterior aspect of the ear at the angle between concha and scapha.



Fig. 6. Incisions are made in line with the antihelical ridge puncture marks (shown in drawing on undersurface of anterior skin of ear) through the cartilage. It is care not to perforate the skin anteriorly.



Fig. 7. a, left, Elliptical strips of cartilage are removed. These vary with the deformity. In general, strip removed in the pinna region from the scapha to reduce the size of the superior portion of the ear and from the concha in the inferior portion. A narrow strip may be removed from the incision along the inferior edge of the triangular fossa but after the incision alone suffices. b, The projecting edge of the concha forms the antihelical ridge after cartilage notches ellipses have been removed.



Fig. 8. The scapha is placed on the concha to correct angle and the overlapping skin is excised on the scaphal side—not in the postauricular sulcus. This preserves the normal sulcus and places the scar line at an angle between concha and scapha.

of an auricular cartilage flap underneath a bridge of pericardium raised on the mastoid process reported by Demel, and the use of fascia lata strip passed under a mastoid periosteal bridge and attached to the posterior auricular surface reported by R. H. H.

Ellner attempted to prevent the ugly wrinkling of the skin in the conchal hollow by opening the perichondrium transversely and removing two triangles of cartilage. None of these operations are recommended and are quoted merely to call attention to the objections of the Morestin operation which they attempt to overcome. In spite of this the Morestin operation is still widely used at the present time. In 1904 Cox advocated this operation because it satisfies the patient. As he put it "the patient wants an ear that does not stick out from the head and does not object if the folds and contours of the pinna are not exactly the

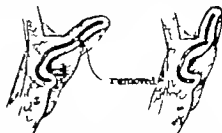


Fig. 9. Neither the cartilage nor perichondrium is removed. If the corrected position cannot be easily maintained by the skin sutures only the deformity has not been corrected and the cartilage incision should be prolonged or more cartilage excised.



Fig 10 a, c, Abnormal protrusion of ears in a woman who desired correction because of thinning of the hair b, d, Postoperative appearance following the Moresstin operation. Note that the ears are closer to the head but the wide conchal scaphal angle is still present.

same as before" In our opinion the only argument for the operation is its simplicity. It should be used only in those instances in which the deformity is slight.

In 1910 Lockett reported an operation which attempted to correct the protrusion and at the same time form an antihelical ridge. He recognized, as he clearly states, that the usual view that the abnormal prominence was due to an increase in the cephaloauricular angle was incorrect. He noted that most protruding ears had a near or complete absence of the antihelix ridge with a shallow or absent triangular fossa. Recognizing the abnormalities in formation of the cartilage he attempted to restore the ear more nearly to nor-

mal by an operation designed to form an antihelix ridge. In the Lockett operation an elliptical excision of the skin is made on the posterior surface of the ear in line with the antihelix. An ellipse of cartilage of the same size as the excised skin is removed with care not to perforate the skin of the ear anteriorly. The cut edges of the cartilage are buckled anteriorly, back to back, to form the antihelix ridge and sewed in position with interrupted stitches in the perichondrium posteriorly.

This contribution of Lockett's was a decided advance and most of the operations described since that time have been modifications and gradual improvements of the concept of forming an antihelix ridge.



Fig. 1. a, c, Excess protuberance which the lateral view shows is due to scaphoconchal angle of about 30 degrees. b, d, The appearance following operation described. The antihelix and the triangular fossa are well formed and the projection of the ear appear normal. The left ear, as corrected, little too much since sight of the helix is partially lost from direct front view.

In 1937 Davis and Krikowski described the procedure which they had used for number of years. This combined the *Morestin* and *Lockett* procedures in that an ellipse of skin is removed from the postauricular sulcus but after the skin is undermined laterally the ellipse of cartilage is removed along the marked outline of the antihelix. The cartilage is then sewed in buckled fashion to form the antihelix as in the *Lockett* operation. From the illustrations in this report it would seem that this operation definitely corrects the protuberant appearance but obliterates the postauricular sulcus to such an extent that the post-

erior view is somewhat abnormal. In addition the lateral views show the antihelix well formed but the scapula is broader and more flat than normal. This flatness is probably due to the post-auricular sulcus excision of skin.

Since this report there have been others which are in the main no different other than in minor details.

MacCollum in 1938 reported a identical procedure which he stated was applicable in all cases of protuberance. In addition he described other procedures. One of these is the *Lockett* operation with no modification other than that an ellipse



Fig 12 a, c, e Preoperative appearance of boy with protruding ears due to increased conchal scaphal angle b, d, f, Postoperative photographs The satisfying thing about the operation which has been described is that, as

in this instance, the ears do not look manufactured The configuration and the position are both normal so that the ear does not appear pinned back when viewed from any position

of skin is not removed He states that this operation is applicable when the pinna of the ear is prominent and the conchal cartilage relatively normal The third method described is essentially the same as the first a combination of the Morestin-Luckett procedures with minor differences in the amount of skin and the shape of the excised cartilage The proximal cartilage is also anchored to the galea where the skin is excised

In 1940 New reported an operation which, as he states, did not differ materially from the procedure reported by Davis and Kitlowski However, there was one thing in this report which was a definite evolutionary step in the right direction He said that in certain instances it might be necessary to remove a separate piece of cartilage along the line of the posterior crura of the antihelix In other respects the operation is the same combination of Morestin and Luckett operations described by Davis and Kitlowski

The same is true of a report by Baxter, in 1941

It will be observed that in most of the operations described there is the objective in more or

less degree of attempting to hold the ear closer to the head The only one that clearly attempts to discard this idea is the Luckett operation in which the attempt is solely to reconstruct an antihelix

The Davis-Kitlowski operation and the various modifications of it still tacitly cling to the idea of approximating the ear to the head, even though an attempt is made to reconstruct the antihelix The reason given by Luckett and by Davis for the reconstruction of the antihelix is that the spring of the cartilage is broken and the folded edges of the cartilage form a buttressing ridge which supports the ear in the more normal position

The operation which we have gradually developed is based on a different concept We believe that the abnormal protuberance is due to an increase in the normal right angle formed by the junction of the scapha and conchal cartilage This makes the antihelix ridge appear less prominent At first sight it might appear that this is a mere toying with words but if this reverse concept of the cause of the deformity is so, then surgery should attempt to change the angle and the recon-



Fig. 3. a, e, Extreme protrusion due to concha scapha angle of almost 90 degrees calls for correction even in a girl. This school girl could not hide her ears with her

hair and was subjected to ridicule by her schoolmates. b, d, f, Appearance after reduction of the scapha-concha angle to approximately 90 degrees.

struction of the ridge which results is secondary. If the wide angle is the sole cause of the deformity then skin excisions on either side of the postauricular sulcus are unnecessary and even to be avoided since they more or less change the normal posterior view and make the ears appear attached too tightly to the head. If the angular relationship of the concha to the head is not abnormal, then excisions of cartilage at the junction of head and concha or attachment of the conchal cartilage to the mastoid galea are incorrect.

Ideally the objectives of the operation should be to set the scapha on the concha at a normal angle, not disturb the normal postauricular sulcus, and to restore the configurations of the ear to normal. The restoration of configurations should be such that, when viewed from the front, the helix is just visible as peripheral margin external to a visible antihelix. If the scapha is drawn too far toward the head, the helix is hidden. Laterally the antihelix should be well formed, the triangular

fovea a definite depression and the scapha normally proportioned.

OPERATIVE TECHNIQUE

Some prefer to operate under local anesthesia but as the majority of these patients are children, we prefer general anesthesia. Although Davis states that he operates with the patient on the face so that both ears are visible, we find that this position is an awkward one for accessing the ear. We drape both ears so that with the patient on the back, the head can be turned from side to side as the operation progresses to compare symmetry. The line of the antihelix is marked out by puncturing the ear anteriorly along the proposed line with a hypodermic needle dipped in methylene blue (Fig. 4). This marking extends up to the beginning of the triangular fovea where it branches to follow the anterior and posterior crura. An incision is then made on the posterior surface of the ear along the crease where the scapha and concha

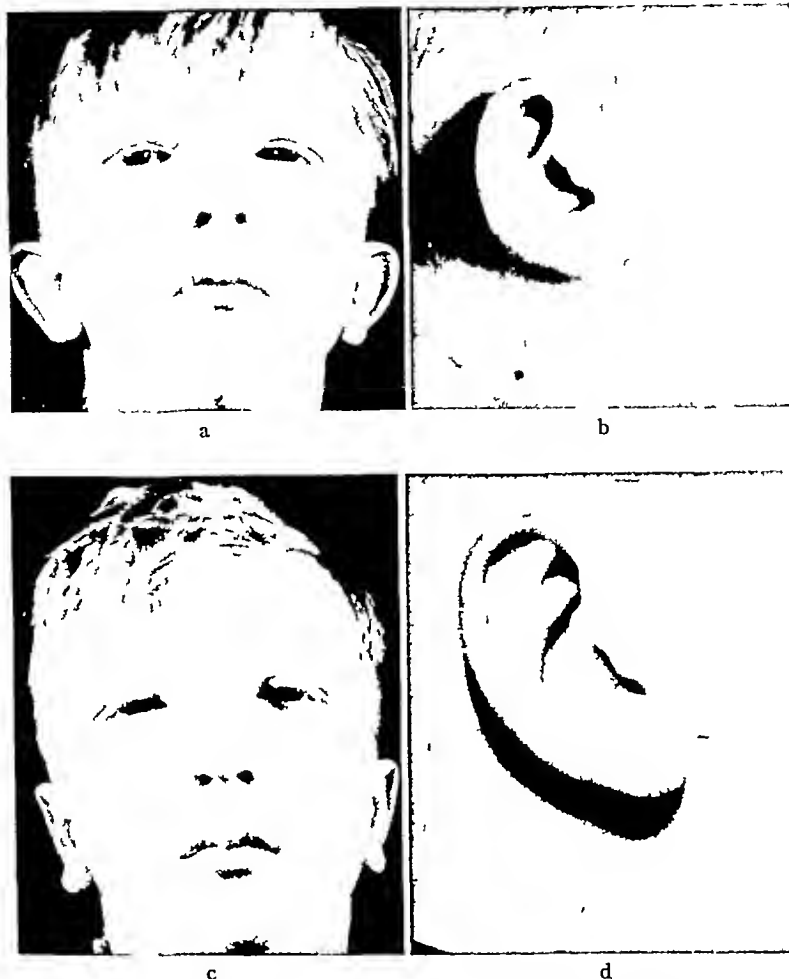


Fig 14 a, c, Minor protuberance of only the pinna. The triangular fossa is formed and in this instance the cartilage incision followed only the superior crus. An ellipse of cartilage was removed from the scapha superiorly and this alone sufficed to correct the condition as shown in b and d

join (Fig 5). The skin is dissected from the cartilage on either side for $\frac{1}{4}$ to $\frac{3}{8}$ of an inch. An incision is made through the cartilage along the line of the marked antihelix, at its superior end the cut follows the line of the anterior crus. A separate incision through the cartilage extends longitudinally through the entire extent of the cartilage dividing the ear into scapha and concha, the only exception being that at the superior end a small bridge of the helix is left (Fig 6). A long thin ellipse of cartilage is removed, in its superior portion this ellipse is removed to the scaphal side of the cut, but inferiorly from the concha (Fig 7). By so doing the pinna and the concha are both

slightly reduced in size. The scapha can then be slipped over the concha so that it rests on it at a right angle. If the incision does not extend the full length of the cartilage, this cannot be done. The scapha will rest on the concha in correct position without tendency to return to the deformed position if the cartilage excisions have been made correctly. If sutures in the cartilage are necessary to maintain correction, the removal of cartilage is inadequate, or the cut has not extended the full length of the cartilage. The cut along the posterior crus is usually sufficient to break the spring of the cartilage and allow the triangular fossa to form. In extreme deformities it may be necessary

to remove a thin cartilage strip along this line. The repositioning of the scapha on the concha causes moderate overlapping of the skin along the posterior incision (Fig. 8). This excess skin is removed and the skin edges are sutured. \ Internal sutures whatever are used. Thus the new line of the antihelix is not formed as in the previous described operations but by the protruding cut edge of the conchal cartilage and the excess of skin anteriorly (Fig. 9). The ears are held in correct position by snug dressings of cotton moistened in saline. This is molded into the posterior sulcus and to fit the external convolutions of the ear. Considerable gauze is packed over this, and the mass of dressings are held firmly in place by a bilateral mastoid type of head dress. This is left in place 10 days, and it should be made certain that it is kept tight at all times. At the first dressing the sutures are removed and a similar dressing is reapplied. At the end of a week this is removed and dressings discontinued.

SUMMARY

Operative attempts to correct abnormal prominence of the ears have fallen into 3 groups: (1) those which attempt to place and hold the ear closer to the head; (2) those which attempt to reconstruct an antihelix ridge; and (3) those which combine the two procedures.

In our opinion abnormal protuberance of the ears is due to the fact that the scaphal portion of the ear is set on the conchal portion at an angle greater than the normal 90 degrees.

This deformity can be corrected and the normal configuration restored by the operation described.

In brief, an incision is made on the posterior surface of the ear at the junction of the scapha and concha. An incision is made through the entire length of the cartilage in this same line following the superior crus at the pinnal end. An ellipse of cartilage is removed to the scaphal side of the incision superiorly and from the concha inferiorly. The scapha is set on the concha at right angles where it will remain without holding sutures. The triangular fossa is formed by an incision through the cartilage along the inferior crus. Skin overlap is excised and the skin is sutured. The antihelix is automatically formed by the cut edge of the concha. Retentive dressings hold the ear in accurate position during healing.

This operation corrects the abnormal protuberance, restores the normal configuration, and does not produce the abnormal appearance of the ear being too close to the head which sometimes results from operations which remove skin from the postauricular sulcus as is shown in Figures 1 through 14.

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VARIATIONS OF THE MALE SACRUM

Their Significance in Caudal Analgesia

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THE pelvis, of which the sacrum is a constituent part, presents the most marked sexual differences in the skeletal framework of the human body. Since there are definite indications for caudal analgesia in urology, proctology, and general surgery and since the widespread application of the procedure by obstetricians (1) may be expected to stimulate its further use in these fields, it is appropriate to study the male sacrum, apart from the female, in its relation to the technical procedure of caudal block.

The purpose of this paper is twofold: one, to present the gross anatomy of the mid-dorsal region of the male sacrum with particular reference to the hiatus sacralis; and two, to point out and examine those features and variations of especial importance in caudal block technique. The data and deductions are based upon observations and measurements made on 553 male sacra of which 296 are white and 257 are negro. The bones studied were chosen at random from some 1,100 male skeletons contained in the Terry Anatomical Collection.

OBSERVATIONS

The laminae of the fourth and of the fifth sacral vertebrae fail to meet in the midline and thus an opening is created at the caudal end of the bony spinal canal known as the hiatus canalis sacralis. Dorsally, the hiatus resembles an isosceles triangle with its base at the level of the middle third of the body of the fifth sacral vertebra and its apex at the lower third of the body of the fourth sacral vertebra. This is the textbook picture and the one most often seen. Variations from this pattern, however, are present in a large number of bones.

In this series the width of the base has a mean of 17 millimeters, it varies from 7 millimeters to 26 millimeters. The length of the hiatus from base to apex is 22.5 millimeters, there is a range from 0 millimeter to 60 millimeters. The apex is located most often at the lower third of the body of the fourth sacral vertebra, it occurs at this level in 32 per cent of the bones. In one-half of

the sacra the apex is at points superior (cephalad) to the lower third of the body of the fourth sacral vertebra, the highest is found at the upper border of the body of the second sacral vertebra. In the remaining 18 per cent it lies at various levels inferior (caudad) to this region, in the extreme cases extending as far inferiorly as the lower third of the body of the fifth vertebra. A male sacrum with a hiatus of average dimensions is depicted in Figure 1a, it presents the same general outline as the typical female (5), but exceeds it slightly in all dimensions. At the apex of the hiatus the sacral canal has as in the female (5) a mean anteroposterior diameter of 5.3 millimeters with a range from 0 millimeter to 11 millimeters (Fig. 1b). This diameter is 2 millimeters or even less in as many as 4 per cent of the bones.

The dorsal bony wall of the sacral canal exhibits a multiplicity of peculiarities. Complete agenesis of this structure occurs in 10 sacra or nearly 2 per cent (Fig. 2), this variation was encountered only twice in 774 female sacra or in less than 0.3 per cent (5). Laminar deficiencies are frequent, superiorly the posterior canal wall may extend only to the level of the body of the third or of the second sacral vertebra, inferiorly, the result of this type of deficiency is a long hiatus (Fig. 3). Apertures (unilateral, bilateral, and seriation) of the canal wall are encountered at many levels. The distance from the apex of the hiatus to these apertures and to the upper limit of the bony wall of those sacra with superior laminar deficiencies is 70 millimeters or less in 26 per cent, 50 millimeters or less in 11 per cent, and 20 millimeters or less in 5 per cent.

Variations are encountered which so alter the bony prominences of the sacrococcygeal region as to make them valueless as a guide to the location of the hiatus, the lumen of the sacral canal may in such instances be of average or of even greater than average diameter. An overgrowth of bone, obscuring or obliterating the hiatus and prolonging the posterior sacral canal wall inferiorly, occurs to a pronounced degree in 5 bones of the series (Fig. 4). More frequently the sacral cornua are absent or markedly flattened. Occasionally a hiatus is seen which is bilaterally asymmetrical (Fig. 5).

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DISCUSSION

The *canalis sacralis* is that portion of the vertebral canal within the sacrum. It occupies the inferior extent of the dura and arachnoid, the lower components of the cauda equina, and the filum terminale. It terminates in the hiatus. The subarachnoid space extends caudally in the canal to the level of the body of the second sacral vertebra (3, 4). Those anatomical features and variations which essentially diminish the distance between the point of entrance of the caudal needle into the canal and the inferior limit of the subarachnoid space are deserving of first consideration in the problem of caudal anesthesia. Latour wrote: "The presence of an unusually large hiatus as the result of the non-closure of the lower half or two-thirds of the posterior wall of the sacral canal, should not be overlooked. In such cases caudal injection should be made with great caution and occasionally avoided because it may prove dangerous to life owing to the risk of puncturing the dural sac and making intradural injection" (Fig. 3). Four additional varieties of sacra whose structure is predisposing to subarachnoid injection are encountered with sufficient frequency to constitute a real hazard if unrecognized. First, the posterior wall of the sacral canal may be open in its entirety (Fig. 5). In such situations the caudal needle can be inserted easily into the sacral canal throughout its length. The complete agenesis of the dorsal wall may indeed represent



Fig. W. U. 529. a, above, Hiatus *canalis sacralis* of typical dimensions. b, Sacral canal with somewhat greater than average anteroposterior diameter at apex of hiatus.

The hiatus or the lumen of the sacral canal may be reduced or blocked at some point by a dorsalward projection from the ventral wall (Fig. 6) by a transverse fold in the posterior wall, or by an excessive flattening of either wall in relation to the curve of the other.

The generally contracted sacrum and the four vertebrae sacrum are characterized by dorsal walls which although completely developed are of markedly diminished length. In the two sacra of this study which are composed of but four vertebrae the dorsal wall lengths are 35 millimeters and 56 millimeters (Fig. 7).

(The photographs for this figure and for succeeding figures were made by Mr. M. B. Rhoaden of the Department of Anatomy.)

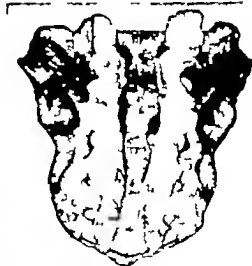


Fig. W. U. 529. Complete agenesis of dorsal bony wall of sacral canal.

one of the rare contraindications to caudal anesthesia because of this very real possibility of piercing the dura. Second, large midline apertures may, through erroneous interpretation of palpation lead to and permit the insertion of a needle at a point superior to the apex of the hiatus and thus in close proximity to the subarachnoid space. Third, the sacrum may be composed of but four vertebrae (Fig 7). This anomaly is particularly important if such a reduction of components is not a result of the lumbarization of the first sacral vertebra but rather of a caudal shift in the sacrococcygeal segments. Fourth, the generally contracted sacrum which at first glance may appear to be perfectly normal, presents a proportionate shortening of dimensions. The needle used customarily in caudal block is 8 centimeters in length. In the four vertebrae sacra of this series the average distance from the apex of the hiatus to the lower border of the second sacral vertebra is 17 centimeters, generally contracted sacra are found in which the measurement is 3 centimeters.

Subcutaneous deposition of the anesthetic agent may occur as the result of dorsal wall agenesis, apertures, and deficient or low-lying superior laminae. Obliteration of the hiatus or canal is due to dorsalward projecting vertebral bodies,



Fig 3 W U 1324 Superior lamina deficiency, a long hiatus in which the apex reaches the level of the lower one-third of the second sacral vertebra.



Fig 4 W U 515 a, above, Bony overgrowth extending the dorsal wall of the canal caudally. b, Anteroposterior diameter of the sacral canal unaffected by the bony overgrowth.

dorsal wall folds, excessive flattening of either canal wall, and bony growth within the hiatus. This last obstructive element which is more pronounced in the male, protrudes as a circumscribed sessile nodule of bone from the posterior surface of the vertebral body (Fig 6). Either a very small anteroposterior diameter of the canal at the apex of the hiatus or complete occlusion at this point make caudal block impossible.

Bony overgrowth (Fig 4), absence of the sacral cornua, and excessively flat cornua mask the normal landmarks of the hiatus. Labat has called attention to the latter variation, he wrote that, "Palpation of the sacrococcygeal region



Fig. W U 96 Asymmetrical hiatus

occasionally fails to give accurate information, because the cornua are comparatively flat or the thickness of the soft structures overlying them is normally great.

The hiatus canalis sacralis is variable in extent and form. The recognition of the outline of the



Fig. W U 97 For symmetrical hiatus

hiatus is a desirable refinement of palpation. Both the recognition and appreciation of asymmetrical types (Fig. 96) are essential if the proper correction factor is to be introduced to insure the insertion of the caudal needle into the midline of the sacral canal. This position is believed to be necessary for the even deposition of the anesthetic agent and consequently for a uniform distributed area of analgesia.⁽²⁾

A thorough knowledge of the anatomical features of the dorsum of sacrum which have been described in this article will inevitably lead to the reduction in the number of failures of the skilled clinician in his administration of caudal analgesia.



Fig. W L 98 (a) left, hiatus with cornua (large projecting module) extending from dorsal surface of body of vertebra; (b) above, projecting module within the hiatus.

SUMMARY

Variations in the anatomy of the mid-dorsal region of the sacrum and their significance in the administration of caudal analgesia were studied in a series of 553 male bones

1 In 50 per cent the hiatus canalis sacralis reached a level on the sacrum cephalad to the level of the lower third of the body of the fourth sacral vertebra

2 In 26 per cent deficiencies existed in the dorsal wall of the sacral canal which might permit exit of the needle

3 In 4 per cent the anteroposterior diameter of the sacral canal at the level of the apex of its hiatus was 2 millimeters or less

4 Other variations in the lumen of the sacral canal were observed as a reliable landmark for the administration of caudal analgesia was shortened sacrum was noted in the mid-dorsal region of the sacrum

contraction

1 HINCHCO, ROBERT

M. A. S. 1901

2 JARVIS, GASTON

3 JARVIS, OLIVER

Morris' House

The Blade Co.

4 RAYSON, STUART

Nervous System

Saunders Co.

5 TROTTER, MILDRED

Surgeon, Gyn. Obs.

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ACUTE OBSTRUCTION OF THE COLON

IT is conservatively estimated that 20 per cent or more of the patients with acute obstruction of the colon lose their lives. A better comprehension of the etiology, the diagnostic criteria, the pathology and the proper methods of treatment should improve this mortality.

The etiology of large bowel obstruction is quite varied, however a fact worthy of emphasis is that carcinoma produces obstruction in this part of the intestinal tract in 80 per cent or more of the cases. Statistical data indicate that about 10 per cent of all malignant lesions of the colon produce obstruction and of these obstructions 7 out of 8 are in the left half. Obstructions of the colon due to malignant disease occur mainly in elderly persons for 70 per cent of the patients with cancer of the colon are over fifty years of age. Therefore when an elderly patient is sick with an obstruction of the large intestine the most probable lesion is an occluding carcinoma of

the left colon. The next most frequent causes of obstruction here are volvulus, diverticulitis, chronic inflammation, benign strictures and intussusception.

The clinical features of obstruction develop more slowly in occlusions of the large intestine than in those which occur in the small bowel. However when the obstruction has persisted long enough that the blood supply of the intestine is becoming impaired the patient will frequently pass rapidly into a serious state and in a question of hours his condition may become hopeless. The marked biochemical changes which develop rapidly in obstruction of the small intestine are not seen in occlusions of the colon. The diagnosis of obstruction, its etiology and its location can usually be made by an analysis of the history and physical findings supplemented by a scout film of the abdomen.

The proper treatment of obstruction of the large intestine will be modified somewhat by the nature of the pathology producing the occlusion. Obstructions due to bands usually demand only the severance of the band. When due to benign stricture some type of enterocanastomosis around the obstructing segment will usually be an adequate method of treatment. Torsion of the intestine is treated by a reduction or resection of the volvulus thus depending on the viability of the obstructed loop. Chronic or subacute obstructions, occasionally produced by endometrial adenoma, can be controlled usually by surgical attention to the female generative organs or by means of radiation therapy. Diverticulitis seldom produces complete obstruction and an occlusion due to it can usually be decompressed by medical management. Only in rare in-

stances does a surgical decompression become necessary?

Since 80 per cent or more of the obstructions of the large intestine are due to a malignancy, the predominant question to answer is what is the preferable management for a patient with an occlusion of the colon due to a carcinoma. To cure this patient it is necessary to resect such a lesion widely. Experience has proved that a primary resection of the colon should never be done in the presence of an acute obstruction which is due to a neoplasm for it is unnecessary and the mortality is prohibitive. It is vital to recognize that this patient has two conditions—a carcinoma and an acute obstruction—and then evaluate the relative primary importance of each. The carcinoma is a slow growing, chronic lesion which has existed for months while the obstruction is an acute process of only hours' duration and will soon prove fatal unless relieved because the circulation of the intestinal wall is endangered by it.

Certainly the immediate institution of measures to protect the viability of the intestine is of primary importance. Research studies appear to confirm that, as long as the bowel is viable, transperitoneal absorption of toxic products and permeation of the intestinal wall by virulent bacteria do not occur. The chief factor threatening the viability of the intestine in the majority of obstructions of the large bowel, when strangulation obstructions are excluded, is the increased intraluminal pressure from colonic distention. Temporizing measures and prolonged attempts to relieve this condition by medical treatment frequently will force such a patient to accept a hazardous rather than a relatively safe surgical decompression. Certainly then, the imperative need of the patient is an operative procedure which will relieve this distention. A cecostomy or colostomy in the transverse colon is indicated,

and when such an operation is done promptly with little manipulation and without exploration it will usually prove to be life-saving.

When proper evaluation is made of what a surgical decompression does for such a patient, the rationale of the procedure becomes apparent for it will relieve the distention and then normal blood supply to the bowel will be restored. The infection within the intestinal wall will subside. Also the number and virulence of the bacteria in the lumen will diminish greatly. The ulcers on the mucosal surface will heal and the edema of the intestinal wall will disappear frequently restoring a patent lumen at the point of the constriction. When this occurs it will permit cleansing of the colon by a through and-through irrigation. The general effects obtained are that the biochemical changes will become normal and the nutritional status of the patient will again be restored.

The obstructed colon usually is decompressed adequately for a safe resection later. A functioning cecostomy or colostomy prevents colonic distention following the resection when it is performed, and thereby avoids tension on the suture line and impairment of the blood supply to the anastomosis. It aids healing of the resected colon by keeping it at rest. The patient with a functioning cecostomy can safely take food soon after the resection. The mortality for the resection of the obstructed left colon will be diminished greatly when a preliminary decompression has been performed.

The reason for the high mortality which accompanies primary resections of the obstructed colon will be more readily understood when the local and general status of the patient is given consideration. Such a patient is in a poor physical state to undergo a major surgical operation because there is marked intes-

tinal distention the blood supply to the intestinal wall is impaired. The tissues are edematous and friable; there are ulcers of the mucosa. Infection is present within the intestinal wall and the lumen of the bowel is teeming with highly infectious bacteria predisposing to peritonitis. The proper healing of the anastomosis following a resection will be doubtful. Furthermore, this patient is dehy-

drated, somewhat starved, and is becoming exhausted, and there even may be signs of impairment of the general circulation with impending shock. When due concern is given to these facts, the hazard of a primary resection of an obstructed colon will be comprehended more fully, and the wisdom and urgent need of a first-stage surgical decompression will be appreciated. G. A. BRIDGES

students and associates, make this of me potential source of keen enjoyment and of invaluable reference to everyone interested in neurology.

H. W. MACCOW.

THE new 760 page volume entitled *The Hospital Modern Society* is the means of bringing the thinking of the leaders of the hospital field together in book form. The material has been obtained from periodicals of special interest to hospital administrators, from the *Transactions of the American Hospital Association* as well as from proceedings of various

institutions. The subject matter has been extremely carefully selected, well organized and correlated into pertinent chapter and topic headings.

It is gratifying to note that the editors have been well aware of the need for attention to the philosophical and social side of the concepts of hospital administration. When one sees such names as Goldwater, MacEachern, Munger, Bucirk, Faxon, and many others, the reader is assured of the quality of the volume as well as the diversity of opinion.

This book will assume a high place in the published works of interest to hospital people and will be an especially valuable reference book. It should be in readily accessible place in every administrator's library.

ROGER W. DEBRY.

THE HOSPITAL IN MODERN SOCIETY. Edited by Arthur C. Bucknery, M.D., and Gerhard Hartman, Ph.D. New York: The Commonwealth Fund, 1943.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

A TEXT BOOK OF PHYSIOLOGY. Edited by E. T. Bell, M.D. 5th ed. Philadelphia: Lea & Febiger, 1944.

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THE SURGICAL CONSTRUCTION OF 80 CASES OF ARTIFICIAL ESOPHAGUS

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CICATRICAL strictures and obliterations of the esophagus following chemical burns are not common, but they attract attention and interest because, in the majority of cases, they concern young adults or children doomed either to continual painful dilatations or to a miserable gastric fistula existence

The majority of 80 patients operated upon and over 200 examined in consultation and treated for strictures of the esophagus were between the ages of 17 and 20 years. Many cases resulted from suicidal attempts of young women, several occurred in young Red Army soldiers of the engineering corps who drank caustic soda from alkaline accumulators mistaking it for water, and not a few children were treated who had drunk strong alkaline washing solutions, or the sulphuric acid from the bottles placed between window panes to keep them clear of frost during winter months.

To analyze and discuss the principles and methods of treatment of fresh esophageal burns is not the purpose of this paper. Dilatation of strictures by means of semihard bougies and elastic dilatation by means of rubber tubes are well known methods. They are used as pre-

liminary steps in the treatment of cicatricial strictures of medium gravity. Often seemingly impassable strictures yield to the action of semihard conic dilators, and many times remarkable results have followed elastic dilatation of extensive strictures of the esophagus by means of rubber tubes inserted along a swallowed thread, introduced through the mouth or through the gastric opening.

However, these methods do not solve the whole problem. In many cases such treatment is not successful, either because of the length of the cicatrix along the esophagus, the thickness of the cicatricial tissue, or because of complete obstruction even to the passage of the thinnest ureteral catheter. In such instances conservative treatment does not succeed or simply cannot be applied.

It has been said that stricture of the esophagus with complete obstruction is practically never found, that all strictures can be cured by persistent, skillful dilatation. Therefore, it has been stated that there are no direct indications for the surgical operation of constructing an artificial esophagus. In our experience, however, we have encountered many cases of impassable strictures in the cervical portion of the esophagus, or even in the pharynx, which terminated in a blind sac, inside which neither a thin probe nor direct esopha-

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gascopy could detect the smallest fistula leading downward.

Presumably if proper measures are instituted immediately after the burn has taken place it will be possible to secure a direct siphon passage from the pharynx into the stomach. However it should be stated that first of all it often happens that the stomach too has been burned by the caustic soda and may require an emergency operation before it becomes clear what the fate of the burned esophagus will be. Sometimes, the degree and extent of the gastric surface burned are so great that the stomach can be considered a total and irreparable loss. If one succeeds with great difficulty and risk in fastening an anterior gastroenterostomy upon the remaining part of the fundus (which is sometimes found in the deepest part of the subcostal space in the form of a thin-walled, swollen balloon the size of an egg) no gastric wall remains for the adjustment of the gastrostomy and the fastening of the rubber tube.

Examples of severe stomach burns in which the esophagus remains intact are rather numerous. In such cases the caustic soda has been swallowed down very quickly, has passed through the esophagus without injuring it, and has remained entirely in the stomach because of the spastic contraction of the pylorus. However as these cases have no direct connection with the problem of burns of the esophagus, we will not discuss them at this time.

A second point is that we cannot make up for the time lost or correct the mistakes of others who treated the esophageal burns when first received. In most cases our patients came from other hospitals, far distant from Moscow some months or even years after the accident; they are fed through gastric fistulas as they have absolutely impassable esophageal strictures.

The question of dilatation of recent esophageal burns still remains unsolved. Professor A. N. Kryoukov who has had considerable experience in the medical department of our Institute declares that (1) early dilatation should be applied only in the cases of moderate general intoxication and (2) passability is presumed to be secured in those cases in which the mucous membrane is not burned through-

out but only in limited parts of the esophagus. However when the necrotic mucous membrane sloughs away from top to bottom as a "corking" or over a considerable length of the esophagus, one cannot rely upon a sufficient regeneration of the mucous membrane even with early energetic dilatation with soft bougies.

Finally the third objection concerns the late results after dilatation of strictures. Our experience with esophageal foreign bodies has shown that a large number are found in patients suffering for many years from partial strictures of the esophagus as a result of burns.

The success or failure of dilatation of old esophageal strictures depends first and foremost on the degree of narrowing, the extension of the stricture itself along the esophagus, the kind of cicatricial changes in the esophageal wall, and the adjacent mediastinal cellular tissue. The gravity and extent of esophageal lesions depend in the main on the quantity and concentration of swallowed liquid.

By the early application of soft rubber dilators or of flexible bougies passage can be secured and excessive stricture prevented only in cases of local or superficial burns of the mucous membrane. In the presence of complete necrosis of the whole thickness of the mucous membrane neither intelligently used prostheses nor early dilatations can secure regeneration of the mucosa or prevent cicatrization and wrinkling of the naked muscular wall.

Therefore conservative treatment is practically hopeless not only in cases of complete obliteration of the esophagus but also in the ever recurring severe strictures which show improvement only for short periods and exhibit pronounced general and local reactions to dilatation. One must choose between the patient existing with a permanent gastric fistula or having the operation of antethoracic esophagoplasty.

CHOICE OF THE METHOD OF OPERATION

The antethoracic cutaneous plastic proposed by Blicher in 1894 is quite expedient and involves a lesser number of operative stages. The only dangerous moment of the procedure comes when the upper part of esophagus is exposed for the neck stoma. In fact, the mobilization of the pharynx or of the cervical part

of the esophagus, to say nothing of the dissection and closure of the distal end, introduces the possibility of infection of the cellular tissue of the mediastinum. But this cannot be avoided in any other method of esophagoplasty.

The objections to this method in so far as there may be a lack of peristalsis in the cutaneous intestinal tube can now be absolutely refuted, our experience is now sufficient to prove that the cutaneous tube allows the passage of food of any kind in a passive but satisfactory manner. Rarely do esophaguses constructed of jejunum allow the rapid passage of swallowed food. More often, the unavoidable surplus of intestine in comparison with the length of the mobilized mesentery causes, if not a stasis of food, at any rate a varying multicurved course along the antethoracic region. Peristalsis of the intestine is energetic, and if no obstacles are present, such as strictures or curves along its course through the abdominal aponeurosis or in the abdominal cavity, evacuation will be sufficient but may be a little slow.

Two other defects of the Bircher operation may be mentioned: first, the capricious behavior of the definitive gastric stoma that is created to make connection with the lower end of the cutaneous tube, and, second, the difficulty and insecurity of the plastic operations required to close the lower end of the cutaneous esophagus.

What could be easier than to make a definitive lip-like gastric fistula when one can bring out, through a corresponding opening in the abdominal wall, the gastric wall, fasten it without strain, and carefully join and sew together the mucous membrane with the skin? It is quite extraordinary but such a fistula displays an irresistible tendency to narrow. It often happens that a well made fistula will, in a month or two, become more and more narrow, requiring repeated excisions of circular callous cicatrices. For fear of possible narrowing, the fistulas may then be made too large. This practice has resulted in a rich flow of gastric juice, escape of food into the dressing, and maceration of the skin not only around the fistula but also within the limits of the whole dressing. Sometimes painful dermatitis developed and resembled a large belt around the

abdomen, sides, and even back of the patients. Patients were afraid to take food because of the gastric secretion which inevitably escaped and burned the skin like fire. Patients became very thin, could not sleep, and did not know how to lie down without irritating the inflamed skin.

The quite natural tendency to free the patient as soon as possible from such suffering by joining the fistula with the cutaneous tube is made difficult for two reasons. First, as has been mentioned, large gastric fistulas may unexpectedly become so much narrower that new operations to enlarge them are made necessary, second, often the abdominal skin surrounding the fistula has become so irritated that the very thought of a plastic junction of the lower end of the artificial esophagus is out of the question and operation must be delayed until the dermatitis can be brought under control by the application of ointments.

But even when the condition of the skin has improved, the fistula finally formed, and the tendency to become narrower has disappeared, any method to close the lower end of the artificial esophagus can result in some failure, for example, in a small but complete fistula, it is extremely difficult to close such a fistula, it is absolutely impossible to set it up by twisting in the separated edges inside and by sewing the mobilized skin over it. The failure is unavoidable and inevitable. Instead of a small fistula a large one will be formed, and there will be an even larger quantity of dead cicatricial tissue surrounding it. Every new operation among these cicatrices makes less and less promising the chance for final success.

These stages of the Bircher operation have become real causes of despair for the surgeon as well as for the patient. Many patients have been subjected to countless operations and have become disfigured by the many cicatrices and the application of all kinds of Filatov grafts taken from the thighs and forearms.

If in connecting the gastric fistula one joins the side flap obliquely, the coincidence of the deep sutures on the tube, along the whole line of exterior sutures, is avoided, and failure of the fistula happens much less often. We use this as the method of choice not only in opera-

tions upon the upper part of the esophagus and when the pharyngeal stoma is joined with a transplanted section of intestine but as well for the closing of the cutaneous segment if the intestine does not reach high enough on the neck. The skin of the neck around the pharyngeal stoma is very seldom macerated and the digestive action of the saliva on the catgut is insignificant. Therefore plastic closure of the upper part of the cutaneous esophagus occurs in most cases without the formation of complete cicatricial defects, and is successful.

It should be emphasized that unexpected repeated narrowing of the gastric fistula can take place after its closure into the artificial cutaneous esophagus. Then operations for the excision of the cicatrices are necessary and the outcome of these repeated plastic procedures seems even more doubtful because vascularization of the areas involved has become insufficient as a result of the former operations. In connection with all this it is quite clear that surgeons who have experienced all these difficulties are not tempted by the seeming simplicity of Bircher's operation but rather prefer to choose other methods which promise fewer difficulties and would seem to assure better results.

Some ingenious modifications of Bircher's operation should be mentioned. Riesenkauff begins the construction of the esophagus not by preparing the cutaneous tube extending from the neck to the epigastrium but by forming both definitive stomas — the pharyngeal and the gastric. These stomas should be patiently observed and should undergo all necessary corrections if they show any signs of narrowing. When it is clear that both openings have become stable and will permit the passage of any kind of food, Riesenkauff closes them at once into the cutaneous tube which he separates by one oval incision, covering half the circumferences of both stomas and, at the same time, building the entire cutaneous tube on the breast and neck. The twisting in and suturing of the mobilized edges of this flap enclose the whole length of the cutaneous tube and both its ends. The enormous oval defect of the skin is then covered by drawing together the greatly mobilized lateral surfaces of the skin.

Some years ago when we made our first 6 artificial esophaguses using the Bircher method we began the operation by building the whole cutaneous tube so as to accomplish the most aseptic part of the construction on an absolutely clean skin. Perhaps that is the reason why we did not have the slightest infection and both the interior tube as well as the covering skin healed perfectly. In the Riesenkauff method, the enormous cutaneous plastic operation is done on a patient having two stomas. In any case the skin around the gastric opening is macerated and it is doubtful that it can undergo sufficient preoperative cleansing. If as is quite possible infection should start under the sutured skin near the gastric stoma, the phlegmonous process would develop upward along the entire cutaneous tube. The entire plastic procedure would then fall asunder and the cutaneous flaps would revert to their former places after the necrotic cellular tissue had moved away. It would not be easy to repeat such an operation on the same patient because of the risk of activating a dormant infection in the large cicatrices. Success after a second operation would doubtlessly be less probable than after the first attempt. Even worse. If one hesitated to repeat an operation performed after the method of Riesenkauff because he feared to mobilize large cutaneous flaps along the entire zone of a recent infection, might not the same reflections make it difficult for him to perform an operation done in accordance with any other method? Personally we have never used the method of Riesenkauff because in case of failure no other method could be used and the patient would be irretrievably disfigured.

The method of Riesenkauff contains in one single operation the three separate stages of the classic method of Bircher. The modification introduced by J. Jianu however is concerned only with the method of constructing the internal cutaneous tube. A flap is cut from the abdominal skin in the shape of a rectangle with an upper base. This cutaneous flap sutured together is bent over and inserted into the subcutaneous tunnel on the chest. If this subcutaneous tube is not long enough to reach up to the neck, Jianu recommends constructing a second one from the scapular re-

gion, bringing this tube across the shoulder, and introducing it so as to meet the first one in the same subcutaneous tunnel. At the junction of the two cutaneous tubes the tunnel is opened by means of a small transverse incision and the open ends of both tubes are sutured together around their entire circumference.

By the use of this method the formation of cicatrices on the chest is avoided and also the method could be used even to lengthen the upper end of the intestinal esophagus if in a slender man there is not enough skin for a cutaneous plastic in the clavicular zone or under it. However, the vascularization of the transposed cutaneous tube through the only remaining narrow part of the rectangular flap would be less sure the greater the length of the tube. The main difficulties in closing the upper, and particularly the lower, end of the cutaneous esophagus remain the same as in the original Bircher method.

Beck, Carrel, A. Jianu, Halpern, and Rutkowski used flaps from the anterior wall of the great curvature of the stomach, drawing the newly formed gastric tube into the subcutaneous tunnel across the costal edge. The gastric stoma is thus displaced from the epigastrium to the middle of the sternum. Furthermore, a Bircher cutaneous tube is necessary. At the cost of a large and complicated laparotomy, a few centimeters of a quite safe cutaneous tube are saved. The gastric fistula has the same disadvantages which result from corrosive action of gastric juice on the skin.

Even less tempting are those operations in which the whole, or nearly the whole, stomach is used as plastic material. The reflection of the mobilized stomach, by the method of Fink-Henschen, and the insertion of the pyloric section into the subcutaneous tunnel antiperistaltically affords no particular advantages but does represent a very serious operation.

Even more complicated is the operation of Kirschner the transplantation of the whole mobilized stomach into the subcutaneous tunnel even as high as the neck in order to make a direct junction with the cervical part of the esophagus. But what is most frightening of all are the difficulties encountered in making the anastomosis between the cardiac and the jejunum.

As is often the case in surgery, good ideas come to different authors simultaneously. Before Cezar Roux in Lausanne in 1907 made the first attempt at total antethoracal esophagoplasty by mobilizing the jejunum with the mesentery, Tavel in Berne recommended the use of a short mobilized intestinal loop instead of a simple gastrostomy to feed patients. One end of the loop had to be joined with the stomach, the other drawn out, thus building a large definitive intestinal stoma. The operation of Roux was welcomed with enthusiasm and immediately found many adherents, particularly in France. But the successes attained with the method were not great, partly because of the difficulties of the operation itself and because of the necrosis of the mobilized large intestinal parts, but mainly because most of the operations were undertaken on cancer patients.

The first successful case was the operation performed in Moscow in 1907 by Peter Herzen. In 4 months he succeeded in making an artificial esophagus for a woman who had poisoned herself with sulphuric acid. Herzen added very important improvements to the methods of Roux: (1) unilateral exclusion of the mobilized intestine with anastomosis instead of bilateral exclusion used by Roux, and (2) the passage of the intestine through a slit in the mesocolon and gastrocolic ligament in order to prevent the possible compression by the transverse colon on the way to the subcutaneous tunnel. Herzen joined the intestine with the stomach by an anterior anastomosis.

The difficulties and risk in mobilizing such an intestinal segment so that it would be long enough for direct junction with the esophagus in the neck caused surgeons to look for compromises. It was Lexer who in 1908 combined the operations of Tavel and Bircher and dissected the intestine with its mesentery as far as possible without the risk of devitalization, and then constructed a cutaneous esophagus. Attempts also were made to use the transverse colon instead of the jejunum, antiperistaltically (Vulliet) or peristaltically (Kelling). Figures 1 to 10 illustrate schematically the various operative procedures proposed.

After a critical analysis of the numerous methods one can say that there are two reliable operations the total intestinal esophagus

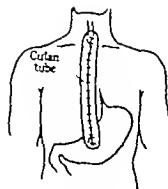


Fig. 1. Birger.

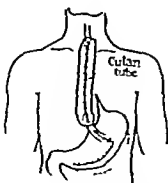


Fig. 2. Beck-Carrel-Juan Halpern.

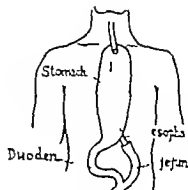


Fig. 3. Kirschner.

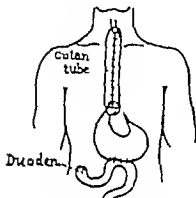


Fig. 4. Fink-Hershen.

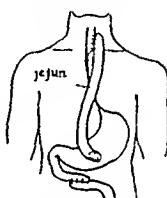


Fig. 5. Roux.

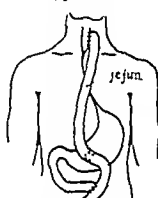


Fig. 6. Peter A. Hensen.

Fig. 7. Schematic drawings of the various operative procedures.

plasty of the Roux-Hershen type and the combined operations of Wullstein, Lexer, Blaucl. One has to choose between them: the choice depending upon the peculiarities of the individual case. In our own experience the total intestinal plastic of the Roux-Hershen type has been found to come nearest to the ideal. Exclusive of the temporary gastrostomy and the possibility of its closure, the construction of the esophagus itself can be accomplished in two stages. In the most successful cases this may be accomplished in 15 to 20 days, with an interval of 5 days between the transplantation of the intestinal segment on the neck and its junction with the pharynx. Of 14 such operations 4 were completely successful in 3 other cases in which the direct anastomosis with the pharynx was accomplished in one operation one was a great success and the other

was a failure. Total intestinal plasty can be very difficult, very risky, or absolutely impossible. The difficulties depend (1) on the excessive fat in the mesentery, (2) the narrowness of the mesentery, or (3) on a particularly unlucky disposition of the radial vessels and of the mesenteric arcades. The greater the experience and skill of the surgeon in the dissection of the mesentery and in the manipulation of its vessels, the easier it is to mobilize a sufficient section of the intestine without any special risk. But there are some cases in which the greatest skill is doomed to failure: the arcades are too short, their junctions are extremely thin, the radial trunks are in many places insufficiently developed, unequally distributed, the mesentery is too fat and easily tears. It is a grave risk under such unfavorable conditions to try extensive mobilization

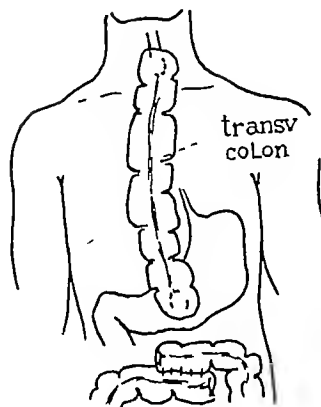


Fig 7 Vullhet Kelling

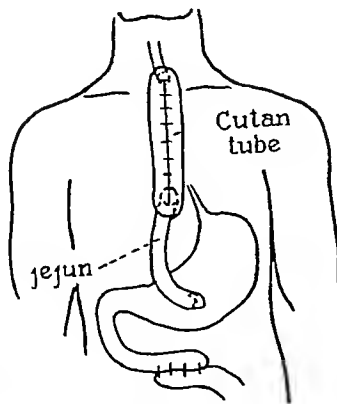


Fig 8 Lexer

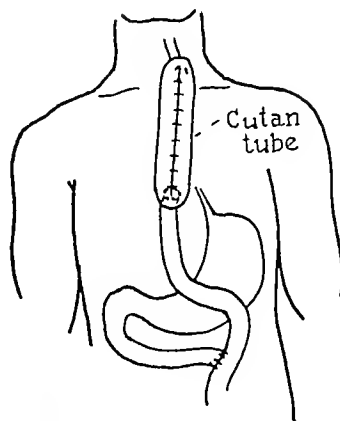


Fig 9 Wullstein

It is better to abandon the idea of doing a total intestinal plastic operation and instead to insert into the subcutaneous tunnel up to the middle of the chest a segment of intestine about 50 centimeters in length which has been separated without any particular difficulty. Another important obstacle to the performance of a total intestinal plastic is the strictures of the esophagus which may be situated high in the neck or even in the pharynx. In the presence of such strictures, junction with the intestine is simply impossible because there is nothing with which to make an anastomosis.

These cases are best handled by (1) the Roux-Herzen transplantation of the intestine on the neck as high as possible in order, in later stages, to construct an artificial esophagus at a point where the pharyngeal stoma and the intestinal opening are situated close together, or by (2) a combination of the Wullstein-Lexer operation with a short intestinal segment and the Bircher long additional cutaneous tube.

CHOICE OF OPERATIONS

A total intestinal plastic operation is the most perfect and is practicable in strictures located below the middle of the cervical section of the esophagus. The construction is carried out in two stages excluding gastrotomy, viz the exteriorization of the intestine onto the neck and its direct anastomosis with the cervical portion of the esophagus. These two stages should not be united into one be-

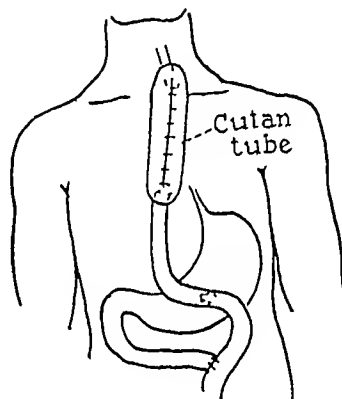


Fig 10 Blauel

cause this would involve a tremendous additional risk of infecting the whole subcutaneous tunnel at the point of the anastomosis.

CASE REPORT

In a lean man, aged 30 years, with complete obliteration of the esophagus at the level of the aortic arch, caused by lye burns, the mobilization of the arch, caused by lye burns, the mobilization of the intestine proceeded easily and smoothly. Very rapidly a segment sufficient to be drawn out above the clavicle was separated. The adjoining vascular arcade was a powerful one, and the radial vessel feeding it was of large size. They were followed, however, by another large and long arcade with a large radial vessel issuing from the root of the mesentery. The adjoining radial vessel was isolated and compressed with an elastic gastric clamp covered with rubber tubes. After it was noted that the blood supply was sufficient, the compressed vessel was dissected, an anastomosis was made, and the intestine was drawn out through a slit in the mesocolon. Assistants had

meanwhile separated out the cervical section of the esophagus. Through the cutaneous tunnel the intestine was drawn up and out onto the neck. A large anastomosis was done without difficulty. The small rubber drains were brought out of the corners of the sutured skin, the inner end of one directed to the mediastinum, the neck and the other to the angle between the vertebral column and the mobilized posterior wall of the pharynx.

The postoperative period was uneventful. The drains were left in place for 5 days and showed local suppuration. For 3 days some saliva oozed through the upper fistula, but all secretions had ceased by the 11th day and by the 15th day the wound was completely healed. The sutures on the abdomen were removed on the 8th day. Intake by mouth was successful and 3 weeks after the operation the patient was discharged from the hospital.

Despite this first success it was a long time before the one stage operation was repeated. Apart from the obvious risk of infecting the newly made subcutaneous tunnel there is the added risk of pulmonary complications. Repeated successes, however, and astonishingly uneventful convalescent periods after two stage plastic operations were instrumental in inducing us to renew the temptation. The next operation was not so successful. The mobilization of the intestine was easily performed there was even a surplus of it on the neck. The cervical section of the esophagus was exposed without difficulty or hemorrhage and a large anastomosis was made. The drains at the angles were away from the line of the actual anastomosis. The immediate postoperative period was perfectly smooth and non-febrile. Local subcutaneous reaction on the neck, however began as early as the 3d day necessitating removal of some of the cutaneous sutures. Beneath them lay the intestine evidencing violent peristaltic movements. It may have been this ultraturbulent peristalsis which drove the local infection inward from the neck wound along the fresh subcutaneous tunnel as far as the epigastrium. Numerous wide incisions had to be made to drain the extensive antethoracic cellulitis. The anastomosis on the neck gradually disrupted and the end of the intestine fell away completely. Although the drawn out intestine retained its vitality for a long time little hope remained after the acute phlegmonous process had ceased of placing it in the proper manner under the skin of the chest. After many months of suspense a

cutaneous anastomosis was made and the operation was completed by using the combined method.

Mobilization and Transplantation of the Intestine

The operation is performed under spinal anesthesia 0.8 to 1.0 cubic centimeter of 1 per cent procaine being injected for adults at the level of the 12th thoracic spine. The anesthesia is invariably efficient, reaching the level of the mammillary line and sometimes higher. In the most recent cases, we have infiltrated the subcutaneous cellular tissue with 1 per cent procaine prior to the moment of forming the subcutaneous tunnel. The solution is injected with long 12 centimeter needles upward from the border of the anesthesia to the left side of the neck as far as the mastoid process.

The gastrostomy tube is removed after the liquid has been evacuated with an aspirator. The opening in the abdomen is plugged fairly tightly with coal-tar gauze mesh.

A small laparotomy incision is made 7 to 8 centimeters upward from the umbilicus. There is no need to make an incision of greater length since (1) the subcutaneous tunnel can be easily prepared with the help of a special instrument and (2) since we have abandoned the final gastroenterostomy there is nothing to be done in the epigastrium itself.

Extreme difficulties arise if the gastrostomy has been performed along the linea alba and not on the left, pararectally. Laparotomy must be performed either by entering below the umbilicus, or the medial gastric fistula must first be moved to the left pararectally before mobilization of the intestine is carried out.

We begin to inspect the mesentery from the upper end 8 to 10 centimeters away from the duodenojejunal flexure. It is not advisable to go lower lest a loss in the length of the mobilized intestine be incurred. On the other hand it is not worth while to ascend any higher for two reasons: (1) because it will be difficult to anastomose the short proximal end into the side of the intestine below the mobilized point and (2) the advantage gained is insignificant as it is all at the cost of the intestine and not of its mesentery which at this point narrows and contains the last remnant of radial vessels.

If this area is left at the end of the mobilized sector, almost the whole remnant will be caught in one common ligature—it will be found to contain a large portion of the intestinal tube which curves round the end of the dissected mesentery, the mesentery proper will not become longer and this is the principal requirement.

The secret of success lies in a maximum utilization of the mesentery lengthwise. Not a single ligature of the vessels should involve the serous layers of the mesentery, both sides of the mesentery must be dissected with a knife along the avascular field and with scissors over the areas where the incision of the mesentery layers crosses the radially located vessels. These sections of the mesenteric layers must be made archwise parallel to the central arcades of the mobilized portion, a protective margin of from 1.5 to 2 centimeters in width being left. These adjoining arch-shaped incisions of the mesentery join in front of the large radial vessels which are to be dissected. The trunks must not only be separated out as far as possible, i.e., as near as possible to the root of the mesentery, but besides this all around them the mesenteric cellular tissue with the lacteal and small blood vessels must be cut in portions which require the finest ligatures. It is not until after the large trunks have been separated out cleanly that they are clamped, dissected, and ligated. The stump with the arcades will run inward into the mesentery under the edges of its dissected peritoneal surfaces. The steep vascular arcades will straighten out somewhat, and the free edges of the mesentery will be able to stretch out lengthwise.

Every succeeding arcade and every succeeding large radial trunk is treated in the same way. If sufficient length of mesentery and intestine seems to have been mobilized to reach to the neck the upper end is dissected between two crushing clamps. The duodenal end is left *in situ*, while the intestinal end is immediately closed. It is now time to assess the length, to see if the mobilized mesentery will allow the intestine to extend without any tension as far as the mastoid process. In case the length is inadequate and dissection and ligation of the next arcade and the trunk nourishing it are

doubtful, then before proceeding further the gastric clamp with rubber covered tubes should be introduced. Without denuding the vessel and through a small incision in the mesentery along the avascular field, the clamp should be closed to compress the vessel temporarily. In most cases the intestine immediately begins to show stormy peristalsis. It sometimes happens that this is immediately followed by cyanosis of the entire isolated segment of intestine or along one or two arcades of the closed upper end of the intestine. The cyanosis may reach an alarming stage during the first 15 to 2 minutes. This should not, however, lead to undue haste in removing the soft clamp. We have on many occasions observed that peristalsis in the intestine continues or the intestine reacts vigorously to tapping and in a short time the entire intestine regains normal color and the vessels of the mobilized mesentery pulsate adequately. The vessel now can be safely dissected and ligated.

Before the tunnel is made an anastomosis of the duodenal end of the intestine with the distal end of the mobilized segment must be made. This short portion lies to the left of the medial line, and therefore an end-to-side anastomosis must be made into the left semicircumference of the distal intestine. The incision in the distal intestine should not be made opposite the line of attachment of the mesentery but vertically, i.e., perpendicular to the long axis, from the middle of the intestinal circumference along the whole left semicircumference as far as the mesentery. Into the gap thus formed in the intestine the end of the duodenal segment is sutured end-to-side. The mesenteries are also sutured together.

After a change of gloves the formation of the subcutaneous tunnel is carried out. For children a long forceps, preferably a curved one, may suffice. For adolescents, or little girls, a large powerful Graser gastric clamp may be sufficient. Pushing these instruments under the skin and separating the branches, the surgeon is able to reach a point in the neck above the clavicle. Should the instrument be not long enough, an attempt is made to bend the patient's head and neck, thus allowing the instrument to penetrate still further and by the separating of the branch of the instrument

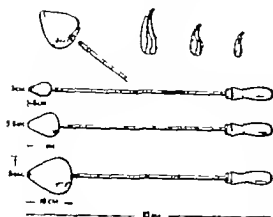


Fig. 12. "Lap" instruments used in making the subcutaneous tunnel.

the tunnel is completed. With tall patients these instruments are not sufficiently long. In such patients the skin on the neck near the angle of the jaw may be opened with a separate incision, and a tunnel is made to extend in the opposite direction—from above down to meet the first.

In order to obviate opening the skin which would have to be closed again I have constructed special iron rods tipped with screwed on special heart shaped and slightly curved ends of 3 sizes (Fig. 12). At the moment when the assistants lift and hold up by means of sharp hooks both skin edges of the upper angle of the laparotomy wound these rods are pushed into the tunnel thus easily separating the subcutaneous cellular tissue and by a simple forward movement finishing the whole tunnel as far as the mastoid process. The whole procedure occupies less than 1 minute. A tunnel of uniform size is produced. The hemorrhage under the skin is insignificant and can be stopped by a large pad of dry gauze mesh introduced by means of the same rod.

Into the tunnel a large Graser gastric clamp is introduced, the tips being pushed to the end of the tunnel on the neck. The branches are opened slightly, the skin of the tunnel being raised by the spread-out ends of the instrument in such a way that these ends may easily be felt and even seen through the skin. Then a straight needle with a long thread is intro-

duced into the skin. The end of the needle is clutched under the skin with a clamp, the needle is pushed inward drawing after it the thread which is painted with iodine as it enters the tunnel. Taking out the clamp through the entrance into the tunnel, we extract the needle and grasp the thread which has passed the whole way through the tunnel from above. It remains only to fasten to it the ends of the "tobacco pouch stitch" at the end of the closed intestine and to begin drawing the intestine into the tunnel.

It must be understood that this thread only directs and gently pulls the intestine with the mesentery into the cavity of the tunnel. The entrance to the tunnel is separated widely and with the use of the fingers the intestine with the mesentery is inserted, smoothed out and pushed into the tunnel with particular care taken not to twist the mesentery along the axis. The procedure is made easier if simultaneously the intestine is gently pressed and massaged through the skin of the tunnel.

In almost every case insertion of the intestine with mesentery is accomplished rapidly and without any difficulty. When the end of the intestine has reached the very end of the tunnel and the stump of the intestine can be palpated there through the skin, the end of the thread drawn out through the puncture is tied over a piece of gauze, and the abdominal wound may be closed (Figs. 12, 13).

In 1 or 2 cases on the 4th or 5th day after operation a small hematoma or aseptic wound secretion from the whole enormous tunnel was seen to have accumulated at the lower angle of the wound. A suture or two had to be removed from the skin to release the accumulation. On 2 other occasions small portions of the omentum fell out together with the evacuated aseptic hematoma. On rare occasions for the prevention of such a accumulation a drain with an exit through the lower end of the wound can be used for 4 hours.

On several occasions however we observed a certain stricture in the artificial esophagus at the level where the intestine passed through the aponeurosis into the abdominal cavity without any other complication having occurred affecting either the wound or the tunnel in the postoperative period. It has rarely



Fig 12

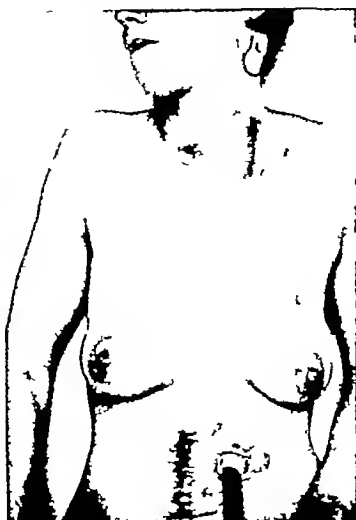


Fig 13



Fig 14

Figs 12 and 13 The intestine with mesentery has been inserted, the end of the string tied over a piece of gauze, and the abdominal wound closed

Fig 14 Successful reconstruction of esophagus in a girl aged 14 years, after numerous unsuccessful attempts had been made to construct an antethoracic esophagus

happened that stasis of this kind in the reconstructed esophagus reaches such a degree as to necessitate additional surgical measures. Such a state, however, would continue for months or even years and would be clearly manifested not only by x-ray examination with a constant medium but would be visible even to the eye after every food intake. There would result considerable distention of the lower portion of the antethoracic esophagus and intensified peristalsis of the intestinal loops (Fig 34).

The same defects were repeatedly noted even more plainly in cases in which this condition was not the result of complications of the operation but were inherent in the method itself. These arguments are equally applicable to both the Roux and the Herzen methods as originally performed. In 3 cases the end-to-side anastomosis of the new esophagus with the stomach, after the method of Roux, was performed. Each time the terminal loop hung down on its mesentery below the large curvature regardless of whether the junction had been made with the anterior wall of the stomach or the posterior, i.e. through the mesocolon. The latter loop of the intestine expanded considerably with food intake and periodically, in large peristaltic waves, would

evacuate its contents into the stomach through the anastomosis. It seemed almost as though there were two stomachs, a natural and an artificial one formed by the dilated terminal loop of the artificial gullet.

The result was even worse with the Herzen method of anterior anastomosis with the intestine. In each case a vertical anastomosis, i.e., from the lesser to the greater curvature, was made. The opening was sufficiently wide to permit the unhampered passage of consumed food into the stomach; nevertheless it was just at this point that in many cases trouble lurked. The loop lying above the anastomosis, not being in any way attached within the tunnel, evidently descended under the skin below the gastrojejunostomy, thus producing considerable constriction with inevitable stasis following. As a result, the anastomosis not only failed to ensure the passage of food into the stomach but even seriously hampered its passage along the constructed esophagus.

In the Herzen method the anterior gastrojejunostomy might be performed either at the first stage, i.e. transplantation of the intestine, or as the concluding step, for instance, in cases of operative closure of the temporary existing gastrostomy. The enlarged opening

of the latter might be used for the junction with the new esophagus. The idea is logical and even appealing and yet this concluding step proved always to be very complicated and to involve considerable risk. It was no easy task to identify and mobilize among the numerous adhesions the tortuous intestinal loop and to draw up from the left the mobilized gastric fistula for anastomosis.

From the point of view of the amount of time and strain such an operation presented greater difficulties than the construction of the esophagus itself. We have long since come to the conclusion, therefore, either to make such a junction immediately during the first stage of the operation or to omit the anastomosis altogether. At present we are abiding by the latter decision for the following 4 reasons: (1) The anastomosis entails an undesirable additional interference which complicates the first difficult stage of esophageal construction. Interference is all the less desirable since the operation is performed on a level with the very root of the mobilized mesentery, and at the risk of introducing infection the junction must be made *in situ* in direct proximity to a huge cellular wound at the entrance to the tunnel. (2) The step is difficult if such junction is made by means of a repeated operation. (3) The anastomosis may be doubtful and at times, even poorly functioning and thus falls short of its purpose and hampers the passage of food along the constructed esophagus. (4) Finally the uselessness of such a junction. Experience with dozens of patients who have for many years taken nourishment through the new esophagus, thus excluding the stomach, has convinced me of these facts. We have observed no disturbance in metabolism, in hemato-poiesis, or in growth or development in children.

All these factors have influenced me in deciding on the present operation as the one of choice—either the Herzen method but without gastroenterostomy in cases in which it is possible to transplant the intestine sufficiently high and the pharynx allows direct connection of the intestinal esophagus with a cutaneous portion added but without gastroenterostomy.

AKASTOMOSIS OF THE INTESTINE WITH THE PHARYNX

The operation is performed with bilateral paravertebral anesthesia of the cervical plexus. From 20 to 30 cubic centimeters of a 1 per cent novocain solution are injected into the zone of the transverse processes of C III i.e. along the posterior border of the sternocleidomastoid muscle at the level of the angle of the lower jaw. It is always easy to orient oneself by means of the needle as to the exact bony structure. The novocain injection must be supplemented by anesthetization of the mucosa of the pharynx and of the entrance to the esophagus either by painting with a 5 per cent solution of pericaine or by injecting from 3 to 6 minims of this solution into each nostril with the head thrown back.

The cutaneous incision is made along the anterior edge of the sternocleidomastoid muscle away from the peristaltic and easily palpable intestine. The cervical part of the esophagus is exposed in the usual manner i.e. after the omohyoid muscle is dissected with care to avoid the main vessels medially and not to disturb the cellular tissue covering it.

The upper thyroid artery almost always must be divided. In most cases the lower thyroid artery must also be ligated and sectioned in order to obtain free access to the esophagus. After careful hemostasis the esophagus is easily separated from the friable prevertebral cellular tissue and when the intestine is mobilized from the upper end of the subcutaneous tunnel the anastomosis can be made.

The latter may be performed in three different ways: (1) side-to-side (2) end-to-side or (3) the end of the dissected esophagus may be joined to the side of the intestine. We have tried all three ways and have discarded two of them. Anastomosis of the end of the intestine into the side of the esophagus is not difficult to perform by cutting off the invaginated end of the intestine. In this procedure however the size of the opening is limited by the transverse dimensions of the intestine. It is clear that in the side-to-side anastomosis the opening can be made considerably wider than the transverse diameter

of the intestine. The idea of an anastomosis of the dissected esophagus into the side or obliquely into the intestine seemed to have possibilities. If the long proximal end of the esophagus could be drawn forward sufficiently, the junction itself could be made after the manner of a Witzel gastric fistula.

As previously stated we have totally abandoned both types of terminolateral anastomosis, basing our decision on the following facts. In order to attach the proximal end to the intestine the esophagus itself must be cut across. First, this is not as simple as it seems, and second it gives rise to serious apprehension with regard to the distal end. If in the latter there should exist any filiform fistular passage downward hermetic suturing of the distal end despite technical difficulties may be performed in the hope that the mucous secretion in the stump will drain through the fistular passage into the stomach. If, however, obstruction of the esophagus is complete, closure of the distal end would create an enclosed cavity and there would be the danger of an empyema with possible rupture into the mediastinum or pleura. There remains only the method of attaching the distal end of the esophagus to the lower angle of the wound. This step of course, would gravely disturb asepsis and would introduce additional risk in the postoperative course. Should everything proceed smoothly and the blind retrosternal end of the esophagus not prove to be too long or spacious, there is still the possibility of attempting later to eliminate this fistula by doing away, in several stages, with the mucous membrane beginning with the bottom of the sac.

It is readily apparent that transplantation of the end of the dissected esophagus is not only a task involving difficulty and risk, but the method has an important constructive drawback. Of 2 cases, 1 ended in late failure and the other in disaster.

CASE REPORTS

A girl, aged 14 years, was admitted to our clinic after numerous unsuccessful attempts had been made to construct an antethoracic esophagus. She had been fed through a gastrostomy for a number of years and when admitted had a countless number of scars on the breast, abdomen, and neck. On the

thorax a Bircher skin tube had narrowed in places so that it hardly admitted a fine bougie, in other places it had fallen to pieces, leaving gaps from 2 to 3 centimeters each in breadth. The entire cutaneous plastic tube had to be done away with, the scars excised, and the skin returned to the original sites.

After a 3 weeks' interval the intestine was drawn from the abdomen onto the neck. The end of the intestine reached to the mastoid process where it was attached to the skin under a star shaped scar, marking the point of a former and now completely overgrown esophagostomy.

A week later the second stage of the operation was performed. The proximal end of the esophagus was freed from the profuse scars as far as was possible, so as to implant the esophageal end with sufficient ease into the intestine, thereby promptly terminating the constriction.

Complete success was achieved, and the girl was soon afterward transferred to another service for studies on digestion and metabolism. Later food was given by mouth to preserve the gastrostomic fistula for some months to come (Fig. 14).

She returned 1 year later with almost complete obstruction of the new esophagus where it joined the intestine. It appeared that as swallowing gradually grew more and more difficult, she resorted with greater frequency to her customary manner of feeding, namely, masticating her food in the mouth and then spitting it out into the funnel inserted in the gastric tube.

At operation the junction was found surrounded by numerous scars. The anastomosis was separated and it was found that the caliber of the opening had remained 1 to 1.5 centimeters in diameter. Instead of enlarging the existing junction it seemed best to make two definitive stomas, in the intestine and the esophagus respectively, both large in diameter. A month later the stomas were covered with a cutaneous flap, and the patient left the clinic perfectly able to swallow any kind of food and with the gastric fistula forever closed.

A boy, aged 8 years, who had been taking food through a gastric tube for 5 years, was so emaciated that for 6 weeks he had to be fed with cod liver oil and vitamins. He withstood well transplantation of the intestine onto the neck under spinal anesthesia. In the second stage the fruitful child would not allow the anastomosis to be performed under regional anesthesia alone, and so in addition to the cervical block he was given light ether narcosis. The intestine on the neck was in excellent condition, and we succeeded in segregating the cervical part of the esophagus without hemorrhage. Intending to attach the proximal end into the intestine we cut across it between two crushing clamps. The upper part was anastomized successfully with the intestine, and it was decided to attach the distal part to the lower angle of the wound. To achieve this, it was necessary to pull, with a piece of gauze, energetically at the clamp to free the esophagus from the surrounding cellular tissue, with a view to drawing out the esoph-

agua sufficient to suture it without removing the crushing clamp for some days. And here during these manipulations sound, suspiciously resemblingpiration of air in breathing, was heard. The sound seemed to be coming from under the clavicular region, and immediately rupture of the pleura was suspected. It was dangerous to draw out the esophagus any further and yet the mobilized portion might not suffice for attachment to be made without removing the clamp. The attachment of the esophagus to the angle of the wound was efficiently performed but it was not possible to force placing drain into the entrance into the mediastinal m.

On the 23d day the temperature rose precipitately by evening reaching 40 degrees C. The clinical condition as alarming there as rapid breathing and some cyanosis. He died on the 25th day. Necropsy revealed a purulent empyema of the right pleura caused by a slight rupture at the point here it was closely attached to the esophagus and the air of a completely impassable stricture.

Had side-to-side instead of the terminolateral anastomosis been chosen the anastomosis would have been performed with greater ease and with much smaller risk.

Terminolateral anastomosis of the intestine with the esophagus is easier to perform because there is no need to dissect the esophagus transversely. We have used this procedure on two occasions when there was a surplus of intestine in the subcutaneous tunnel on the neck. Not only is the size of the junction in such cases limited to the transverse dimensions of the intestine but the actual direction of the attached intestine perpendicular to the length of the esophagus and to the normal flow of food creates conditions scarcely favorable to the passage of swallowed food from the esophagus into the intestine. It is obvious that the food eaten will pass first almost wholly along the esophagus as far as the stricture and it is only after the blind sac is overfilled that it begins to evacuate its contents into intestine.

There seems to be no way of avoiding such a contingency in the side-to-side anastomosis. However such an anastomosis can be made larger than if the terminal method is used and also the attached intestine will come to be parallel to the esophagus along the whole length of the anastomosis. In any case conditions for evacuation will be much more favorable.

Nevertheless the falling of the swallowed food into the blind end of the esophagus is

totally unavoidable a fact which gives rise to two questions (1) to what extent does the phenomenon disturb the new esophagus, and (2) is it possible to remove this blind sac by any special means?

The first question can be answered from personal experience. Never once have these blind sacs caused our patients any particular annoyances despite the fact that in some cases the sacs were quite large as may be seen by the x ray pictures (Figs. 15, 16, 17, 18).

The explanation may be that these blind sacs can be regarded in no way as pathological diverticula of the esophagus with destroyed muscular wall and progressive hernial protrusion of the mucous sac. Above the strictures in most cases our patients have an esophagus that is not only sound but that even has a somewhat thickened muscular wall due to hypertrophy.

It may be that such hypertrophy may partly persist even after evacuation of contents of the esophagus into the intestine in so far as the blind sac is compelled uninterruptedly to free itself by the eructation upward of food masses that have passed into it toward the opening of the anastomosis. Our observations over a number of years lead to the conclusion that these blind sacs show no tendency to extend either in length or in diameter nor have we ever observed ulceration caused by retention of food.

As to the second question—the possibility of eliminating the blind esophageal sac below the anastomosis—our arguments are purely theoretical, since neither with curettes nor electrolysis have we ventured to perform demucosation in our patients. The same applies to the burning of the mucous membrane with chemicals, such as chromic or carbolic acid through the esophagoscope. The burning would seem to be practicable and if it is begun from the bottom of the blind sac and is carried out in several stages, a complete obliteration might be attained. The procedure requires experimental confirmation in order to determine the requisite concentration of the caustic solutions and to determine how extensive an area can be burned at each successive step. We have so far never had occasion for such subsequent manipulations as the

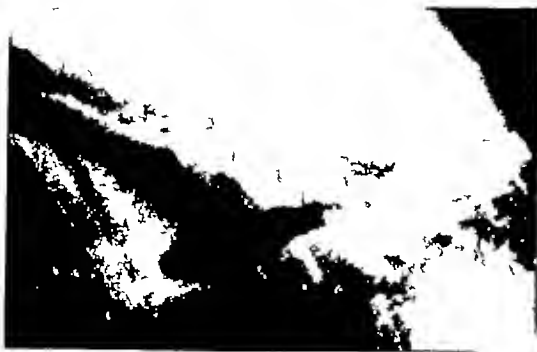


Fig 15



Fig 16



Fig 17



Fig 18

Figs 15, 16, 17, and 18 Blind sacs in esophaguses

strictures were never below the arch of the aorta and the remaining blind sacs were consequently not overlarge. Should need arise, efforts might be made to achieve obliteration of the esophageal sac even after construction of the intestinal esophagus. Introduction of the esophagoscope should not be particularly difficult as we have twice had occasion to discover in other patients in extracting large plum stones that had caused choking.

CONSTRUCTION OF PHARYNGEAL STOMA

Construction of the pharyngeal stoma is one of the most difficult tasks in the reconstruction of the esophagus. We have to deal with cases in which it seems impossible to make a direct junction of the pharynx with the drawn-up intestine, and in which the high level of the stricture make the possibility of building a new esophagus questionable. Besides complete obliteration of the esophagus, the patients have had severe burns of the

laryngeal orifice and were in danger every moment of dying of asphyxia.

In 4 cases when the patients were admitted to the hospital they had already had a tracheotomy. Moreover, in 2 other of our patients the question of an urgent tracheotomy arose during the construction of the esophagus. One patient had been on the point of being placed on the operating table for tracheotomy 6 times during the period when the unfortunate girl was being fed through a jejunostomy. After consultation with an eminent laryngologist it was declared that there was no hope of restoring breathing otherwise than by means of tracheotomy. Even less were the chances of building a definitive pharyngeal stoma as the pharynx had become merely a short narrow funnel inside of which the epiglottis was bound by solid scars along almost the entire surface of the posterior wall. Despite the unfortunate conditions it was decided to operate. Cervical anesthesia was



Fig. 9. Postoperative photograph of patient in excellent health after severe burn of the esophagus and pharynx.

used and the esophagus was found to be a solid shaft. The lateral wall of the pharynx was intact and showed elasticity both above and below the hyoid bone. Subperiosteally the entire left half of this bone was removed and the lateral pharyngeal wall could then be isolated. The pharynx was opened and with scissors the incision was continued downward as far as the stricture and upward almost up to the root of the tongue. The mucous membrane and entrance of the larynx were promptly painted with a 10 per cent solution of cocaine. We immediately succeeded in attaching the anterior edge of the incision to the skin by means of several sutures. The posterior edge however could not be drawn out because of the adherent epiglottis. With a scalpel the epiglottis was separated from the mass of scar tissue and we were able to draw out and suture the freed lateral posterior wall of the pharynx to the posterior edge of the skin incision. The pharyngostomy was fairly extensive but out of this large opening the epiglottis protruded in a transverse direction to at least a half of its length. It was feared that very soon grave mechanical disturbances in breathing might ensue that the ability to speak would be greatly hampered and that even the new esophagus itself would prove to be worthless because food swallowed, espe-

cially liquids might find its way into the respiratory tract. All these fears fortunately failed to materialize. The postoperative period was smooth and the patient immediately began to breathe quite freely. In 2 days the epiglottis protruded less from the pharyngeal stoma and began to assume a more oblique position. A week later it had become entirely concealed in the depths of the stoma and lay vertically. The intestinal esophagus was a real success no trouble was experienced with the voice and food did not enter the respiratory tract.

Another patient who also had a stricture high to the pharynx and scar tissue causing stricture of the laryngeal orifice without any ostensible reason began to suffer periodically from asphyxia. The question of performing a tracheotomy of urgency had repeatedly arisen but the patient refused to undergo this operation. The choking paroxysms occurred at intervals of several days and passed without help within a period of 2 or 3 hours. Her general condition was so much improved by feeding through a gastric fistula, and she began to gain so much in weight that it was deemed advisable no longer to delay the transplantation of the intestine lest additional difficulties should arise when the work on the fattened mesentery was begun. The intestine was drawn high up on the neck, the operation being admirably borne by the patient but the attacks of asphyxia recurred. She was then transferred to a special otolaryngeal clinic with the request to undertake treatment of larynx. She remained there for over a month and was sent back. A reconstruction operation at the entrance of the larynx was thought by specialists to be impossible and the patient repeatedly refused to submit to tracheotomy. One morning she was found dead in her bed she had been asphyxiated during one of her attacks.

In another patient a burn of the pharynx precluded every hope of making a stoma for the reconstruction of the gullet and at the same time the narrowing of the orifice of the larynx by scars was so great that removal of the tracheotomy tube was out of question. Operation was begun with the cervical stage so as to avoid intestinal transplantation

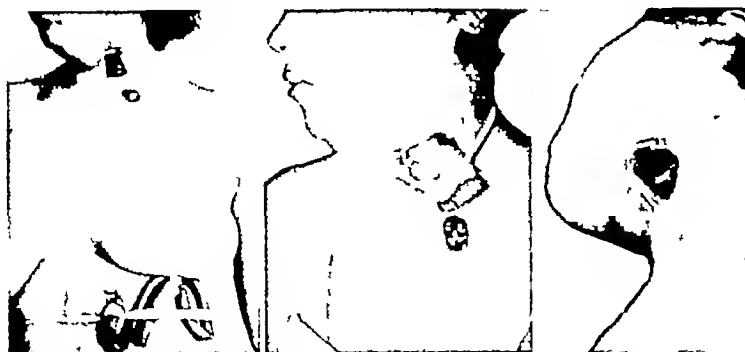


Fig 20

Fig 21

Fig 22

Figs 20, 21, and 22 Various stages in patient who finally despite loss of most of the pharyngeal muscles could swallow food efficiently and had no difficulty with the reconstructed esophagus

in case of failure of the pharyngeal stoma. Fortunately, partial success was achieved at once in that although the stoma narrowed to such an extent that passage through the tube could be maintained only by means of a permanent rubber drain, on the other hand the freeing of the epiglottis of scar tissue produced considerable improvement in breathing. Improvement continued and at intervals the patient began to do without the tracheotomy tube. By the time the new esophagus was constructed, breathing was good enough to permit removal of the tube. The intestinal plastic operation was successful at once. However, it required 3 additional operations before the pharyngeal stoma finally allowed the passage of every kind of food without hindrance. This patient has remained in the best of health and has an excellent artificial esophagus (Fig 19).

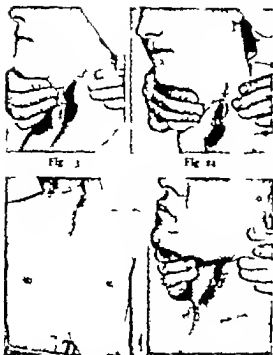
These cases illustrate the great difficulties encountered in these patients both because of the high level of the burn in the pharynx, and because the strictures hamper the respiratory tract. Moreover, irrespective of the circumstance burns situated high in the esophagus produce conditions most difficult to overcome in building a reliable pharyngeal stoma which has some assurance against subsequent narrowing. Just as with the purely cutaneous method, gastric stomas also have the same tendency to become narrow. The stoma begins to narrow almost immediately and often within 4 or 5 weeks an opening that would at first easily allow 2 fingers to be in-

serted in its mouth, will have grown over entirely so that not even the finest probe will pass.

By the subperiosteal removal of one-half of the hyoid bone, the drawing up and outward of the pharyngeal wall is greatly facilitated and the tension on the sutures between the edges of the mobilized pharynx and the skin is considerably lessened. It is necessary to mobilize to a larger extent the edges of the skin, the skin that has been loosened should descend freely into the operative wound to meet the edges of the mobilized pharynx. Since these measures were devised we have used them in every case.

It should be emphasized that the main part of the operation consists in mobilizing the remnants of the pharynx. To obtain sufficient access to it many sacrifices have to be made: the upper thyroid artery must be ligated, and the lingual artery has to be cut, the salivary glands, both the sublingual and submaxillary, have to be removed, and this involves dissection of the external maxillary artery. But these sacrifices are not great ones, and neither is the dissection of the digastric and stylohyoid muscles. It is essential that the large marginal branch of the facial nerve be spared, and they can easily be spared if care is used. The hypoglossal, particularly, and lingual nerves present greater difficulties.

The extent to which the pharynx is mobilized should by no means be minimized in the hope of attaining success at a cheaper price. Should mobilization prove insufficient, then,



Figs. 3, 4, and 5. Patient showing adherence of its openings and position in depths of rect. stoma.

no matter how the edges of the skin have been separated in order to approximate the pharynx, the tension of the sutures will cause the edges of the mucous membrane to separate and to recede inward. The procedure will end not only in a marked narrowing of the stoma which will demand repeated operations, but as frequently happens such a stoma becomes completely grown over and the surface of the wound closes.

Repeated operations of this nature always prove to be far more difficult than is the primary procedure because of the presence of vascular scar tissue, the difficulty of administering anesthetics and the distortion of the organs of the neck making dissection difficult and the danger of injury imminent.

The possibility of injury to nerves has already been mentioned. The lingual artery was twice injured in attempts to dissect it free from scar tissue. The proximity of large vessels, especially the jugular vein, prevented the clamping of the bleeding vessel too tightly

while the degree of hemorrhage suggested injury of a larger vessel. In one case it was necessary to tamponade the wound and we were not able to make an opening into the pharyngeal cavity. Another patient had an excellent intestinal stoma high on the neck, and after great difficulty an opening was made into the oral cavity. We were unable to rely upon the possibility of mobilizing both edges of the concealed pharynx so we were content to attach only the forward edge to the loosened cutaneous flap. Through the opening thus obtained a piece of a rubber gastric tube was introduced, passed sideways near the root of the tongue and drawn outward from the mouth. Both ends of the drain were joined together thus forming a rubber ring threaded through the mouth onto the neck. The patient stoically endured the discomfort for a fortnight until the wound had granulated and partly epithelialized. By means of a set of short wooden cone-shaped dilators to replace the rubber drains within a few days the stoma had been enlarged to great dimensions. Each time after maximum distention was reached the patient herself personally controlling the pressure of the dilators by the sensation of pain, the dilator was fastened around the head by a gauze string and was left in place for several days without being removed. A month later patient could bear a dilator of from 3 to 3.5 centimeters in diameter (Figs. 20-21-22). An enormous opening through which the root of the tongue could be seen was thus produced. Then callous scars beneath the cutaneous edges of this opening were removed and the widely mobilized edges of the skin and mucous membrane of the mouth were drawn up without tension. In four stages at intervals of a fortnight the callous scars around the edges were excised completely and the mobilized skin was sutured securely to the mucous membrane of the mouth and remnants of the pharynx.

It is interesting to note that this patient like a number of other patients who had practically no pharyngeal muscles remaining swallowed her food sufficiently and had no difficulty whatsoever in using the artificial esophagus. All food liquid as well as solid passed rhythmically from the mouth due to

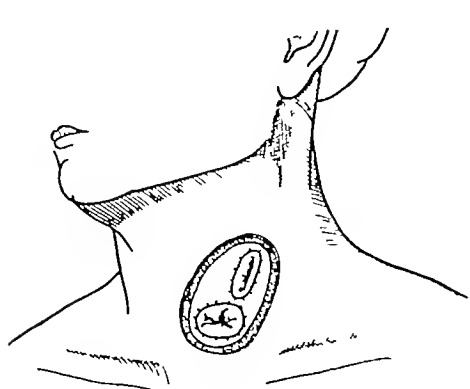


Fig 26

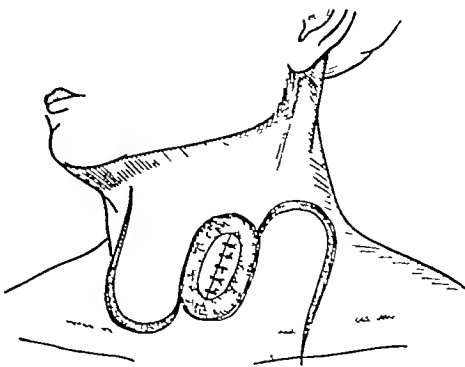


Fig 27

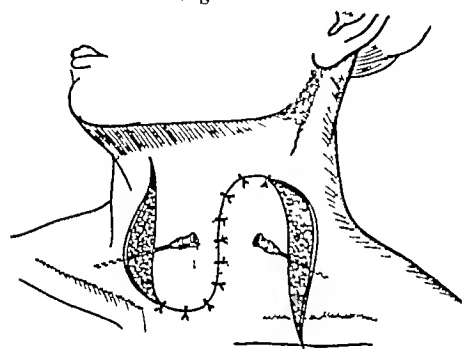


Fig 28

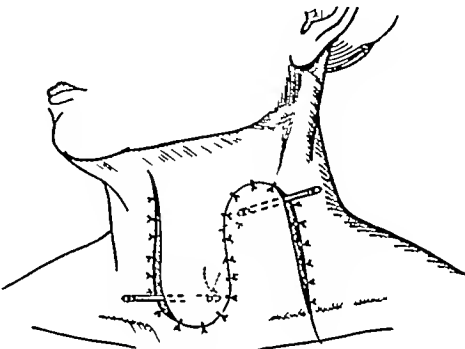


Fig 29

Figs 26, 27, 28, and 29 Various steps in the use of two lateral flaps drawn together diagonally to correct the defect in the neck

the action of the muscles of cheeks and tongue

ANASTOMOSIS OF THE PHARYNGEAL AND THE INTESTINAL STOMAS

It is sometimes possible to make a partial anastomosis of the pharyngeal and intestinal openings as early as the second stage, that is while the actual pharyngeal stoma is being shaped. Sometimes it happens that the segregated remnant of the esophagus does not suffice for complete anastomosis with the segment of intestine now lying in the subcutaneous tunnel.

But usually there are sufficient segments of the esophageal wall or pharynx to make an efficient anastomosis between the lateral edge of the opened esophagus and the medial border of the opening in the intestine. Therefore, we content ourselves with anastomosis of these two organs by one layer of sutures and

attach the free edges to the edges of the skin. As a result the two openings come to adhere, lying in the depths of an excellent general neck stoma. It is thus possible to close the esophagus by means of a small oval or round flap so that the site of the anastomosis is covered by shifting on to it the two lateral oval flaps (Figs 23, 24, 25).

When the stricture is located high in the neck and unavoidable dilatations and plastic correction operations on the pharyngeal opening are in prospect, the intestinal stoma should be formed at some distance to preserve space for any necessary operative corrections of the pharyngeal stoma. In such cases the stoma will be divided by a cutaneous belt 1.5 to 2 centimeters wide. In the plastic closure the cutaneous form will not be round, but oval, along the line of the neck.

It is always easy to conceal the defect on the neck by drawing together the widely sep-



Fig. 30.



Fig. 31



Fig. 32

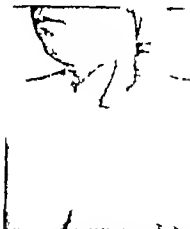


Fig. 33



Fig. 34



Fig. 35

Figs. 30, 31, 32, 33, and 34. Patients after plastic operation with the lateral flaps drawn diagonally together to correct defect in neck.

parated skin edges. There is always sufficient skin on the neck for this purpose. This step, however, should not be undertaken because the line of the sunken sutures closing up the inner wall of the new esophagus coincides in its entire length with the line of sutures which draw together the outer edges of the skin. An inner suture may easily wear through or necrosis may occur in a small section of the skin that was separated for the sinking and suturing of the two stomas. In so far as this point coincides with the unhealed line of sutures on the exterior skin, a straight open

Fig. 35. Patient in whom tubed pedicle flap from the arm was utilized to close the defect in the neck following anastomosis.

fistula may form which shows absolutely no tendency to heal. This fistula will assume shape and narrow down but will not heal and will have to be closed by operative measures. To avoid this unpleasant contingency we have made it a rule to use two lateral flaps drawn together diagonally. After these are sutured together the inner sunken sutures are crossed only in a single place by the line of outer sutures. This gives a much greater guarantee of success (Figs. 26, 27, 28, 29) but it demands the observance of two conditions. First, the free edges of both flaps must not be sutured

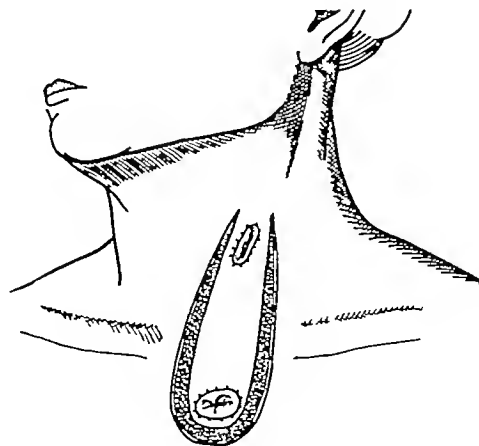


Fig 36

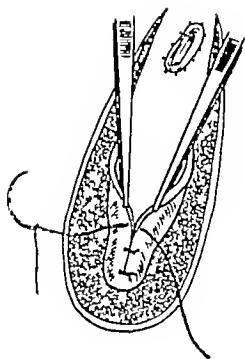


Fig 37



Fig 38

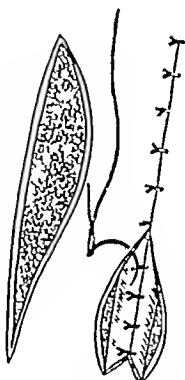


Fig 39

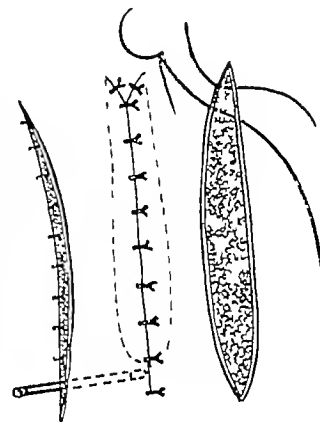


Fig 40

Figs 36 to 40 Steps in the procedure of closing the lower end of cutaneous tube

to anything. However tempting it might seem to close the defects formed in the places of the flaps, such a procedure is admissible only provided the mobilized new sectors of the skin be attached to fascia, to muscles, and not to the displaced oval flaps. These oval flaps must lie in position without being stretched in the slightest degree with their own weight resting on the surface they are covering. Second, since under these conditions the flaps very rapidly grow into the new soil throughout their entire surface, there arises the same danger as is seen in the linear coincidence of the interior and exterior sutures, namely the partial necrosis or the cutting through of the interior sutures will lead to the flaps peeling away and to the formation of a straight open

fistula. To avoid such a contingency, a fine rubber drain should be placed beneath the base of each flap, the ends of these drains should be just short of the line of the interior sutures, and their outer ends should be fastened to the skin. These drains must be kept in place for 7 to 10 days (Figs 30, 31, 32, 33, 34).

CONSTRUCTION OF A CUTANEOUS SUPPLEMENT FOR THE COMBINED METHOD OF ESOPHAGOPLASTY

If the intestine has not been drawn up to the level of the pharyngeal stoma, or if it has proved necessary to resect the intestine because of partial necrosis of its end, the upper portion of the esophagus must be constructed



Fig. 4. left One stage anastomosis between intestinal transplant and pharynx
Fig. 4a. T stage anastomosis between intestinal transplant and pharynx

from skin. Two methods are possible depending upon the length of the remaining gap: (1) when the intestine is drawn up beyond the clavicle or is nearly on a level with it or (2) when the intestine reaches only to the mamillary line of falls even below it.

In the first instance an intestinal stoma must first be shaped by suturing the end of the opened intestine into a transverse oval incision of the skin not less than 3 to 5 centimeters wide. After an interval of at least 3 weeks one may start closing the lower end of the cutaneous tube stretching it beyond the pharyngeal stoma but leaving the upper end open gradually narrowing down the size of the cutaneous tube above the level of the pharyngeal stoma in such a way as to make the opening of the upper open end of the cutaneous tube from 1 to 2 centimeters wide (Figs. 36 to 40).

By closing the lower end of the cutaneous tube a certain degree of risk of infecting it is incurred closing the upper end doubles the risk. Leaving the upper end open is sufficient insurance against any trouble connected with twisting-in the cutaneous well edging the upper semicircumference of the pharyngeal stoma if we try simultaneously to close the latter.

In the second type i.e. with a very long cutaneous tube nothing should be risked even

at the lower end. Bircher's procedure should be followed from the intestinal stoma upward onto the neck, passing above the pharyngeal stoma but both ends of the cutaneous tube must remain open. The upper end should be closed up at the last moment and the lower end of the cutaneous tube must be joined with the intestinal stoma in exactly the same manner as is an oval flap.

RESULTS

Six patients operated upon by the Bircher method (cutaneous esophagus) have had good functional results. One patient died in an interval between the operative procedures. In 2 patients a peptic ulcer developed in the skin of the new esophagus and both resulted fatally later on.

Sixteen patients have had a direct anastomosis made between the pharynx and the intestinal transplant. Eleven cases terminated favorably. One 8 year old child died during the operation and in 4 cases there were various degrees of failure.

Fifty-eight patients have been operated upon by combined methods with 3 deaths during the course of the procedures.

There have been failures demanding alterations and subsequent corrections, the repeated and at times exhausting plastic operations on

the pharyngeal stoma have already been mentioned. It was often necessary to trim the edges of the intestinal stoma. On 5 or 6 occasions open fistulas were formed in the cutaneous tube but all were successfully closed with a Filatov's pedicle graft.

The fate of the transplanted intestine is of much greater interest. In 1 case there was a failure in a one stage total esophagoplasty due to an infection of the tunnel. In 3 cases the reverse situation existed, i.e. there was infection of the tunnel due to partial necrosis of the intestine. In 2 cases of this type, during an uneventful postoperative period with excellent peristalsis along the whole transplanted intestine, on the 5th to 7th day there appeared a well marked and sharply limited discoloration of the skin along the upper end of the tunnel. The temperature did not rise and the patient's general condition remained excellent. The flush increased in intensity, the skin in that sector became glossy, and incisions had to be made. An apparent necrosis of the end of the intestine was taking place. The intestine was resected and the end was sutured to the skin of the chest. The operation had to be finished after a long interval with the aid of a cutaneous supplement corresponding in

length to the necrosed intestine. In the third case of necrosis in a transplanted intestine, redness appeared on the 12th day after the operation without a rise of temperature. Only the day before excellent subcutaneous peristalsis of the intestine had been observed. Unfortunately, in this case the necrosis of the intestine took place along a considerable portion of its length, and it had to be removed to a level immediately above the xiphoid.

Without doubt in all 3 cases secondary disturbances of the blood circulation developed but somewhat late, as the result of stasis and gradual thrombosis of the veins in the terminal arcades. To foresee and foretell this is, in my opinion, impossible, however, such a contingency is of rare occurrence. These 3 cases of partial necrosis of the transplanted intestine occurred in a total of 73 cases.

EDITOR'S NOTE. In July, 1943, Dr. Yudin had completed 88 artificial esophaguses, of these 21 were total intestinal esophagoplasties. The direct operative mortality was 2 out of 88 completed cases.

On July 16, members of the Anglo-American Surgical Mission witnessed completion of the second stage of the operation in Case 89, i.e. the direct anastomosis of the intestine with the pharynx and the first stage in Cases 90, 91, and 92, in all of which the intestine was isolated, transplanted beneath the skin of the thoracic wall, and anchored high in the neck.

CORTICAL KIDNEY TUMOR—ANALYSIS OF 100 CONSECUTIVE CASES

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MALIGNANT parenchymal neoplasms of the kidney offer the least favorable prognosis among the tumors of the urinary tract. It is the consensus that surgery is the only hope of cure and no other method of treatment has been found as yet by which the immediate or remote results could be improved materially.

The prognosis in each case is directly dependent upon the degree of malignancy of the growth and upon an early diagnosis. Unfortunately, lack of characteristic symptoms during the early stages of the disease prevents early recognition of the lesion in a great number of cases. Many patients are seen late in the disease and complete removal of the tumor is impossible because the tumor has spread beyond the kidney or distant metastases have developed. However, even in patients with operable or apparently early lesions, the end results are not encouraging since local recurrences or metastatic spread may occur a few months or many years following nephrectomy. Furthermore the prognosis is made worse by the comparatively high postoperative mortality rate which according to a review of published statistics by Mathé is as high as 19 per cent.

It is obvious, therefore, that the majority of the reports dealing with the ultimate results accomplished in the treatment of parenchymal kidney tumors presents a gloomy picture. Smith and Young in a recent analysis of 97 consecutive cases of malignant kidney tumors found that "most of the patients" died of local recurrences or metastases within 5 years after admission. Those patients who survived the 5 year period died of the disease a few years later. The 5 year survival rate as reported by other authors (Austin, Mathé, Dougherty) varies between 15 and 33 per cent of the cases

with operable tumors. The most encouraging results have been published by the Mayo Clinic (Braasch, Judd, Priestley). The latest report from this clinic (Priestley) is based upon 642 patients with various types of kidney tumors. Nephrectomy was carried out in 568 cases (88.5%) and in the remaining 74 cases an exploratory operation revealed an inoperable lesion. Of the 568 patients who underwent nephrectomy, 395 had cortical epithelial tumors. Forty-seven and seven-tenths per cent of them survived 3 years, 38.4 per cent 5 years, and 27.3 per cent 10 years or more. No other clinic has been able to accomplish approximately as favorable results but it may be assumed that the percentage of operable patients admitted to the Mayo Clinic is higher than would be encountered at other clinics. In contrast, the percentage of operable cases can be expected to be particularly low in cancer clinics, because patients are frequently referred to these institutions with far advanced or recurrent disease. This statement is borne out by the following figures:

During the past 20 years, 100 patients with malignant cortical tumors of the kidney were admitted to the urological service of the New York State Institute for the Study of Malignant Diseases. Metastases or evidence of local recurrence at the time of admission were demonstrable in 53 of these cases. 23 of them underwent nephrectomy or exploratory operation elsewhere prior to admission. Ten, four other patients were unsuitable for surgery because they had fixed and extensive tumor masses. Of the remaining 27 patients, 11 were referred for postoperative irradiation, 9 had moderately advanced but still operable lesions, and only 3 patients were seen in the early stages of the disease. These figures contrast sharply with those presented by Priestley. Only 27 per cent of our series had a chance to be relieved, compared to 88.5 per cent of the patients admitted to the Mayo Clinic.

From the New York State Institute for the Study of Malignant Diseases.

It is obvious, therefore, that an analysis of our results presents a gloomy picture. It is not so much the object of this study to report end-results, rather it is intended to analyze our material as to history, symptoms, and clinical course.

SEX AND AGE

Among our series of 100 patients there were 65 males and 35 females. The more common occurrence of adult cell type parenchymal kidney tumors in males as observed in our series of patients is analogous with the sex incidence given in other statistics (Israel, Hale and Burkland, Smith and Young, Priestley, etc.). The age of our patients varied from 17 to 75 years with 89 between 40 and 69 years (86 per cent between 40 and 70 years—Israel).

SITUATION AND PATHOLOGY

Sixty-one of the tumors originated in the right kidney and only 39 in the left kidney. Preponderant occurrence of kidney tumors in the right side has been found also by Hale and Burkland who reported that 32, or 59.3 per cent of 54 patients with kidney tumors were situated in the right side as compared to 22, or 40.7 per cent, in the left side. Analogous statements were made by Israel and Kuester. However, these figures are not in agreement with Young's observations. In a series of 41 patients in whom the side involved was recorded, Young found that the tumor originated in the left kidney in 22 cases and in the right kidney in 19 cases.

The high percentage of patients with inoperable or metastasizing tumors in our series of cases accounts for the fact that sections for microscopic examination were available in only 45 cases. The sections were studied in co-operation with our pathological department and the following types of tumors were identified: hypernephroma, 16; papillary adenocarcinoma, 24; carcinoma, 4; sarcoma, 1. In the remaining 55 patients the diagnosis of kidney tumor was based on the patient's history and on various findings such as palpable tumor masses and complete urological examination including retrograde pyelograms.

It is of interest that 4 of our 100 patients showed evidence of double primary malignant neoplasm. One patient had been treated

previously for adenocarcinoma of the fundus uteri, another patient had an epithelioma of the larynx coincident with a papillary adenocarcinoma of the kidney, a third patient had a carcinoma of the breast in addition to a hypernephroma, and the fourth patient had a papillary adenocarcinoma of the kidney parenchyma associated with a papillary carcinoma of the kidney pelvis of the same kidney which had metastasized to the bladder.

Although isolated reports on the occurrence of cancers originating simultaneously in a kidney and in another organ or in the same kidney have been reported in the literature (Weissel, Mathé, et al.), it appears probable that multiple primary malignant neoplasms in cases of kidney tumors are of more frequent occurrence than commonly believed. Hale and Burkland, who based their studies on 54 postmortem examinations of patients with cortical kidney tumors discovered two separate primary malignant neoplasms in 9 instances. While such a high occurrence may be incidental, it can be assumed that the number of such cases will increase with further progress in diagnosis and treatment, because many patients, who are being apparently cured from one tumor may live long enough to develop another primary tumor in a different organ.

SYMPTOMS

It has been well impressed on the medical profession that pain, hematuria, and tumor are the cardinal symptoms of a renal tumor. It must be kept in mind, however, that this classic triad of symptoms is encountered as a rule in far advanced cases only. The presence of pain, hematuria, and tumor assured the diagnosis of kidney tumor before the days of pyelographic studies, but, since it represents a late manifestation of the disease, it should be valued rather as a prognostic, than as a diagnostic sign. Pain, hematuria, and tumor were present in 31 of our 100 patients. All of them had far advanced and inoperable lesions. This experience is in agreement with a statement by Smith and Young who found that all their 19 patients, in whom the triad of symptoms was present, were inoperable.

An analysis of the histories obtained in our series of 100 patients revealed that hematuria

alone (15 cases) or in combination with pain (6 cases) or tumor and pain (31 cases) was present in 52 patients. The most favorable prognosis as to possibility of cure was offered by the group of 15 patients with painless hematuria only. Pain (6 cases) or tumor (10 cases) or both (5 cases) without hematuria were present in 21 patients. The remaining 27 patients had no symptoms referable to genitourinary tract prior to time of admission.

In the latter group of 27 cases there was 1 patient in whom the presence of a kidney tumor was discovered incidentally at autopsy following death as a result of carcinoma of the larynx. In the remaining 26 patients the tumor was found when routine pyelograms were made while searching for a primary neoplasm. Seventeen of these 26 patients had pain from metastases to bones or various organs, 3 patients complained of intermittent vague pain in the abdomen and 7 patients had no other symptoms but malaise and loss of weight. It has been stated by Smith and Young that patients with weakness and loss of weight as the initial manifestations of the disease have almost always far advanced and often metastatic lesions when first seen. Our experiences have been analogous. All of our 7 patients of this group had inoperable lesions and died of the disease within 1 year after admission.

The duration of symptoms in 99 of our patients who had various complaints due to the disease varied from week to 35 years. The diagnosis was established in 57 cases within the first year after the onset of initial symptoms. In 13 cases the tumor was recognized between 1 and 2 years after onset, in 6 patients between 2 and 3 years, and in 15 between 3 and 5 years. In the remaining 8 patients manifestations of the disease had been existent from 7 to 8 years in 3 and for 13, 14, 15, 17 and 35 years in 1 patient each.

The occurrence of cortical kidney tumors of unusually long duration has been mentioned by various authors who based their reports on a large clinical material (Israel and Israel, Smith and Young, Cabill and Mellicow, Geschickter and Copeland). Recent case reports by Carlson and Ockerblad, Grant, Smith and others emphasize that some of these tumors may exist for many years with-

out interfering seriously with the patients' well-being. The fact that 8 per cent of our patients presented a history of from 7 to 35 years' duration suggests that such cases are of more frequent occurrence than the literature would indicate. Although the long existence of these neoplasms cannot be proved it may be assumed that the history given by these patients is fairly accurate (Carlson and Ockerblad). This view is supported also by Cabill and Mellicow who pointed out that the initial manifestations of the disease may frequently be present even longer than the history suggests.

The occurrence of these cases indicates that there is a certain number of cortical tumors of the kidney which in spite of definite histological evidence of malignant new-growth, show very slow progress of the disease. These tumors have little tendency to perforate the kidney capsule and as will be discussed later if metastases develop even the metastases have little tendency to progression. Some of these tumors may not affect the well-being of the patients for many years because they exert little toxic effects. They may be discovered incidentally while they are progressing unnoticed or almost unnoticed by the patient or they may be discovered after an acute incident as acute pain or massive hemorrhage. The following case serves as an illustration.

Mrs. A. B. aged 39 years, his female case No. 4508, admitted to our service on May 26, 1913. She stated that she was conscious of tumor mass in the left upper abdomen for period of 35 years. The tumor had not impaired her ability and she noticed no appreciable increase in the size of the growth till 3 months prior to admission. At that time she observed sudden enlargement of the tumor. The patient denied any symptoms referable to the genitourinary tract particularly hematuria.

She was fairly well-nourished patient, body not too fat. On palpation of the abdomen revealed slightly movable, smooth, fluctuating mass which occupied the entire left abdomen and extended all beyond the midline to the right side. The mass contained a fibrous and scattered but blood cells. The patient's hemoglobin was 95 per cent with 4,400,000 red blood cells. The but blood count showed nothing remarkable aside from moderate shift to the left. Cystoscopic examination revealed normal bladder and urologocarcinoma eliminated from the left kidney in fair concentration although somewhat delayed. Pyelogram were barren, none



Fig 1 a, left, and b, above, Tumor removed in the case of Mrs A B The tumor measured 19 by 12 by 10 centimeters in size and was adherent to the dense kidney capsule.

of a large kidney tumor involving the lower pole and the middle part of the left kidney. No distant metastases were demonstrable, and removal of the tumor was carried out through transperitoneal approach on June 3, 1943. Since the tumor had invaded one loop of the small intestines, resection of the bowel loop involved was necessary. The patient was discharged from the hospital on July 8, 1943, after a stormy recovery.

The tumor removed measured 19 by 12 by 10 centimeters in size. On section it was found that the interior of the growth consisted largely of a partially organized blood clot which was surrounded by a thin layer of tumor tissue which was adherent to the dense kidney capsule. A small part of normal kidney parenchyma was present in the region of the upper pole of the kidney (Fig 1a and 1b). Microscopic examination revealed an adenocarcinoma of adult cell type. A section of the portion of the tumor attached to the bowel showed invasion of the serosa.

METASTASES

Metastatic spread of the disease was demonstrable in 65 of our 100 patients. The organs involved in order of frequency were lungs, 29, bones, 20, liver, 8, distant lymph nodes, 7, mediastinum, 6, vagina, 4, skin, 3, adrenals, spleen, cervix uteri and urethra, 1 each. Twenty-nine of these patients had multiple metastases with 4 of them having carcinosis. Single metastatic lesions were found

in 31 patients. In the remaining 40 cases no evidence of metastases was demonstrable in 28 patients and in 12 patients the records were not sufficiently complete to exclude the possibility of metastases.

It is well known that metastases from parenchymal renal tumors are of frequent occurrence. This is largely due to the fact that kidney tumors have the tendency to invade the renal vein even in the early stages of the disease. Such tumor thrombi have been demonstrable in 54 per cent of 509 patients with hypernephroma at the Mayo Clinic (McDonald).

Numerous instances are on record in which symptoms from metastatic lesions were the first indication of the presence of the tumor while manifestations referable to the primary tumor were totally absent. Study of our material revealed that this was the case in 17 per cent of our patients. The fact that 10 of these 17 patients had initial symptoms due to bony metastases suggests that, in spite of the absence of symptoms pointing to the possible presence of a kidney tumor, a complete urological examination should be carried out in all patients with obviously metastatic bone lesions of unknown primary origin.



b

d



Fig. 1. a, Roentgenogram, case of Mrs. S. R. showing bone destruction superior and inferior rami of left pubic bone. b, Filling defect in region of inferior calyx, right kidney, irregularity of borders and rarefaction. c, Evidence of new bone formation. d, Roentgenogram 4 months later revealed slight progression of primary lesion and new area of bone destruction in region of right pubic bone. e, 7 months later, roentgenogram showed extensive areas of bone rarefaction involving superior and inferior rami of pubic bone extending down to ischium.

As to the incidence of metastases it has been emphasized by Hand and Broders that metastatic lesions are more likely to develop in patients with tumors of grade 3 and 4 malignancy. Similar views have been expressed recently by István. Although this conclusion is in agreement with our present conception of malignant tumors, which is, that tendency to formation of metastases represents an indication of high grade malignant tumor, it must be borne in mind that some of these tumors may exhibit little tendency to further progression for many years although metastatic spread of the disease has taken place. We are referring to those patients in whom not only the primary but also the metastatic tumor may remain in a state of dormancy for many years without receiving any treatment. The fact that these tumors may persist for years without showing noticeable signs of progression can be interpreted as evidence of clinically low grade malignant new growth although such a tumor may have all the histological characteristics of a highly malignant growth.

Cases of this kind have been reported by Lehmann, Smyth, and others. Lehmann's patient had a pulsating metastatic tumor of the skull from a primary hypernephroma of the kidney which persisted for 12 years without impairing the patient's well-being. Smyth removed a tumor from the cerebellum which proved to be a metastatic hypernephroma. His patient underwent successful nephrectomy after recovering from the first operation and remained alive without evidence of the disease at the time when the case was reported.

The following case was observed in our series of patients.

Mrs. S. R., aged 57 years, white female, case No. 30802, was admitted to the hospital on December 1, 1937. She gave a history of having gradually increasing dull pain in the region of the right groin of 1 year's duration. Her general condition had remained unimpaired and she denied symptoms referable to the genitourinary tract. Urinalysis revealed a slight trace of albumin and rare leucocytes. An x-ray picture of the pelvic girdle showed a large area of bone destruction involving the superior and inferior ramus of the pubic bone, which was interpreted as being metastatic in nature (Fig. 2a). While a search was in progress for the primary lesion pyelograms were made which revealed a filling defect in

the region of the inferior calyx of the right kidney (Fig. 2b). In addition there was an irregular outline of the right lower kidney pole and impairment of function of the right kidney. In view of these findings a diagnosis of cortical tumor of the right kidney metastatic to the right pubic bone was made. A thorough search for other metastatic lesions yielded negative results.

Treatment consisted of 200 kilovolts of x-radiation over the primary as well as over the secondary tumor. Irradiation resulted in marked improvement in the appearance of the bone lesion coinciding with complete disappearance of pain in the region of the right groin. X-ray studies made at 3 month intervals revealed gradual filling in of the osteolytic bone lesion. A film made on September 13, 1939, showed irregularity of the borders and several areas of rarefaction with evidence of new bone formation in the area affected (Fig. 2c). Pyelograms repeated on January 17, 1940, revealed very slight progression of the primary lesion but a new area of bone destruction in the region of the right pubic bone (Fig. 2d). A renewed course of 200 kilovolts of x-radiation over the symphysis resulted in temporary regression in the size of the rarefied area. However, the last x-ray film made on August 26, 1943, showed an extensive area of bone rarefaction involving the superior and inferior ramus of the pubic bone extending down to the ischium (Fig. 2e). Excretory urograms made recently showed fair elimination of diodrast from the right kidney and no essential changes in the appearance of the right kidney pelvis compared to the films taken 3 years ago. The patient's general health has remained good and she has lost no weight. Her blood count on August 26, 1943 was as follows: hemoglobin, 96 per cent, red cells, 4,800,000, and white blood cells, 12,400. The differential count was normal except for a moderate increase in band forms. Up to the time of writing, the patient had no hematuria or other symptoms referable to the genitourinary tract. On palpation, no tumor was felt in the kidney region and no evidence of metastases to other organs was demonstrable up to the time of writing.

END-RESULTS

Owing to the large number of patients with far advanced or metastatic lesions the results accomplished in our series of cases were most discouraging. Only 13 per cent of the patients survived 3 years, 6 per cent 5 years and 1 per cent 10 years.

At the time of writing 71 of our 100 patients had died of the disease, 59 of them within 1 year after admission. Four patients died of other causes and 10 could not be traced. Of the remaining 15 cases, 11 are alive with the disease and 4 are apparently well. Two of the latter 4 cases have been well

for less than 1 year, 1 for over 2 years, and 1 for more than 5 years.

Nephrectomy followed by external x radiation was the method of choice in the treatment of patients with operable lesions (35 patients). In patients who were admitted with a recurrent or inoperable tumor treatment consisted in external x radiation alone (50 patients). Patients in the terminal stages of the disease when first seen received no treatment (15 patients).

It is the consensus that irradiation treatment in patients with adult cortical kidney tumors is of little value as far as the ultimate outcome is concerned. Priestley, in his analysis of 395 cases arrived at the conclusion

that no significant difference was noted in the survival rate of patients receiving irradiation and those receiving no such treatment. Our results are in agreement with Priestley's experiences. Although dosages of from 3000 to 4000 r were delivered to the tumor (300 kv, 70 cm. skin target distance, 0.9 mm. copper filter half value layer) no more than temporary regression in the size of the tumor was accomplished in isolated cases while the majority of the patients did not respond to irradiation treatment at all. It can be concluded therefore that parenchymal neoplasms of the kidney are radioresistant and the amount of radiation required for their destruction is greater than can be tolerated by healthy tissue.

Study of our material has indicated that the course of an inoperable parenchymal tumor of the kidney is not so much determined by the kind of treatment employed as by the potential malignancy of the tumor itself. Although the majority of these patients die of the disease within 1 to 3 years after onset of symptoms caution should be used in making a prognosis since some of these patients may live quite comfortably for many years before they succumb to the disease.

SUMMARY

Data collected from 100 consecutive cases of cortical kidney tumor are presented.

Seventy three of the patients were admitted with inoperable recurrent or metastatic lesions, and 27 patients had early or moderately advanced tumors.

Only 4 patients are alive and apparently well, 11 are alive with the disease, 10 could not be traced, 4 died of other causes and 71 died of the disease.

Surgery offers the only chance of cure provided the tumor is still operable. External irradiation treatment is of little or no value in the majority of the cases because parenchymal neoplasms of the kidney are radioresistant.

It is emphasized that some of the patients with cortical tumors of the kidney may present symptoms lasting for many years prior to admission. These cases may continue to live for a considerable length of time before they succumb to the disease.

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SURGICAL DIVISION OF THE SPINOTHALAMIC TRACT IN THE MEDULLA

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ONE of the more efficient operative methods for the relief of intractable pain is that of cutting the lateral spinothalamic tract. This procedure combines simplicity of performance and permanency of analgesia without impairing motor functions, and therefore has largely replaced such methods as peripheral neurectomy and posterior rhizotomy. However, even this method has been unsuccessful in certain cases of severe unremitting pain in the neck and shoulder because the pain fibers from these regions are the most deeply placed in the lateral spinothalamic tract and often escape section. For this reason neurosurgeons are ever alert to the development of new techniques which offer promise of producing high levels of analgesia.

In 1941 Schwartz and O'Leary proposed sectioning the lateral spinothalamic tract in the medulla oblongata, much after the fashion of Sjoquist's operation for cutting the descending spinal root of the trigeminal nerve. They claimed to be successful in producing a high level of analgesia and in alleviating shoulder and neck pain in 2 cases. One of us has since employed this operation in 3 cases. In two the tract was sectioned on one side only, but in the third both sides were cut. All of these patients have subsequently died and have come to postmortem examination. The object of this paper is to relate our experience with this procedure, and to offer evidence to show whether or not this new method holds sufficient advantage over other methods to justify its continued use.

CASE REPORTS

CASE 1. The first patient operated upon was a 46 year old white male first seen in December, 1941 at the request of Dr. John Strider. He had complained of cough, sputum, hemoptysis, dyspnea and pain in the chest for 10 months. He was first admitted to the Boston City Hospital on April 20, 1941, by which

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time a diagnosis of carcinoma of the right lung with metastases had been made. An exploratory thoracotomy revealed an inoperable tumor. He was discharged with the chest wound healed, May 10, 1941, suffering from continuous pain in the right chest, dyspnea, and small hemoptyses. The following October, the patient developed severe pain in the right knee and leg, and the foot became cold. He was readmitted in November, and a diagnosis of thrombosis of the right femoral artery was made. During all this period he had been taking increasingly larger doses of opiates without relief from his pain. At the time we saw him he required $\frac{1}{4}$ grain morphine or $\frac{2}{3}$ grain dilaudid at least every 4 hours and sometimes oftener. Physical examination showed the trachea to be deviated to the right as was the mediastinum. The right chest expanded poorly. There was increased fremitus, decreased resonance, and absent breath sounds over the whole right chest. The fingers and toes were "clubbed" and arterial pulsation was absent in the right leg below the knee. There were no signs of neurological disease. Roentgenograms of the spinal column, 2 needle oxygen myelograms, and tests of the dynamics and chemistry of the cerebrospinal fluid disclosed no abnormality. The urine was normal, the blood examination was not made. The blood pressure was 112/86, the temperature 98 degrees, pulse 88, and the respiration 22. The patient's life expectancy was estimated as being 2 to 3 months.

Cordotomy with section of the spinothalamic tract offered the only hope for relief as he had reached the limit of toleration of opiates, and they had lost their effect. Because a classical thoracic cordotomy would not be high enough, and because a high cervical cordotomy might prove ineffectual in rendering the neck and shoulder analgesic, a medullary tractotomy was thought to be the procedure of choice. This operation was performed on January 20, 1942, under local anesthesia, with the patient's head on the cerebellar headpiece and elevated to 45 degrees above the horizontal. The usual trap door incision with an extension across the midline for about 1 inch was outlined in the left occipital region, and the occiput and foramen magnum were exposed and cleaned without difficulty. The occipital bone on the left and a little of that on the right as well as the posterior half of the foramen magnum were completely removed. The dura was widely opened and the left hemisphere, the vermis, the medulla and the upper end of the cervical cord were exposed. The tonsil on the left was loosened and this and the hemisphere gradually elevated and turned upward and medially after the cisterna magna and the

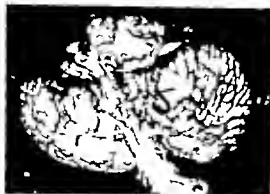


Fig. Arrow indicates the site of the tractotomy. Note that the incision begins in the retro-olivary sulcus and extends posteriorly toward the restiform body.

lateral cistern were emptied and the arachnoid was torn over the 9th, 10th and 11th cranial nerves. The left posterior cerebellar artery was very long, looped to lie on itself and overlaid the field of operation in the medulla. It was mobilized successfully however and the dorsolateral aspect of the medulla with the filaments of the 9th, 10th, and 11th nerves at their points of exit were exposed. There was a small vein in the dorsolateral sulcus. The olive and fibers of the hypoglossal nerve were easily identified. It was decided to cut the upper filament of the 11th nerve to procure more room for the tractotomy. This was done with the cutting electric current. A distance of 4 millimeters was then measured on a cataract knife and marked with bone wax. A point just beside and above the exit of the filament that had just been cut was selected, and the knife blade was inserted straight into the medulla for the 4 millimeters and then depressed and elevated in half circle. This cut the vein in the postero-lateral sulcus, but it did not bleed significantly. The patient had no reaction and testing with a pin on his right side demonstrated complete loss of pain sense about the 6th dorsal and hypesthetic box that level 1 dorsal or 8th cervical segment. The tractotomy was then repeated to a depth of 5 millimeters. This produced pain in the left eye as the posterior end of the arc in the medulla but no further anesthesia. The blade was then inserted to a depth of 6 millimeters. This produced pain in the left eye at the posterior end and pain in the throat. The anterior end of the arc and analgesia to the level of the 8th cervical dermatome. As much had been done as was considered safe by then and no further attempts were made to reach the more deeply situated cervical fibers. The patient had borne no reaction. The blood pressure remained between 50/95 and 70/90, the pulse ranged between 70 and 74 and the respiration ranged between 20 and 25. The wound, including the dura, was closed without drainage and with interrupted silk sutures pentothal being given during the closure. At the end of the

operation the blood pressure was 15/85, the pulse 74 and the respiration 7. At the start the fingers had been, blood pressure 5/90 pulse 155, and respiration 7. The patient responded satisfactorily at the end of the operation. No further narcotics were needed after the 4th postoperative day. On the 8th day he was out of bed, around the 2nd and free of pain. The only complication was some difficulty in swallowing on the 2d day. This disappeared in 4 hours. On the 2d day the upper level of hemianalgesia on the right as to the 8th cervical 1st dorsal segment. By March 8 which was the 10th post-operative day, the upper level had descended to the 5th dorsal. Below this the sensation of pain and temperature was lost and that of light touch was diminished. On April 4, the patient was much weaker and had to be confined to bed. At this time he was disturbed by paroxysmal delirium and required sedation. He died suddenly on April 6, 76 days after the operation.

An autopsy restricted to examination of the brain and spinal cord, was performed 8 hours after death. The pathological diagnoses were left lateral medullary tractotomy, postoperative 11th section of the left lateral spinothalamic tract, the left ventral spinothalamic tract, and parts of the left central tegmental tract, left nucleus ambiguus and dorsal accessory olivary nucleus.

The craniotomy wound was clean, healed, just behind and about 5 centimeter above the lower pole of the left eye. A small notch which represented the site of the tractotomy (Fig. 1) The spinal portion of the left spinal accessory nerve was softened and retracted. Horizontal section of the medulla at the level of the incision revealed linear cavity just behind the left olive. The cerebellum, brain stem, and spinal cord were otherwise normal. No tumor metastases were present.

The entire medulla was cut into small blocks and sectioned serially. Sections were stained by the methods of Nissl and Weid. Representative blocks of spinal cord, cerebellum, pons, midbrain and cerebrum were prepared by the same method.

The operative lesion as best demonstrated at about the midolivary level here it was situated just behind the olive and extended medially to within 1 millimeter of the midline (Fig. 2). At one point it bifurcated and extended forward into the dorsal accessory olivary nucleus. The vertical extent was about 5 millimeters. The left lateral spinothalamic tract, except possibly some of the most medially placed fibers the ventral spinothalamic tract, the central tegmental tract on the left the ventral part of the nucleus ambiguus and the dorsomedial part of the inferior olive nucleus were either destroyed or interrupted. The pyramidal tracts, medial lemnisci, except for few spinal fibers and the spinal accessory tract of the trigeminal nerve were not in contact.

Secondary degeneration of the olivocerebellar and dorsal spinothalamic fibers could be traced to the left restiform body. No other ascending or

descending degeneration was observed (Marchi technique was not employed because of the age of the lesion) Cresyl violet sections revealed large numbers of macrophages at the site of the lesion and gliosis of the surrounding tissue

It is evident from the clinical and anatomical findings that the nucleus ambiguus, spinal nucleus, and the tract of the trigeminal nerve were not damaged to any significant degree. The spinocerebellar tracts, especially the ventral one, were partially interrupted, but no cerebellar signs were produced. Although successful in relieving the chest pain the highest level of the analgesia was only the cervical 7th-8th. Thus some of the most medially placed fibers, those just decussated and conveying sensation from neck and shoulder were not severed at the operation.

CASE 2 The second case was a man of 57 years, seen April 13, 1942, in consultation with Dr Somers Fraser. He complained of pain and swelling of his left leg. This had started in September, 1941, to be followed shortly afterward by the appearance of a mass in the left groin. This mass was removed in October, 1941, and a diagnosis of epidermoid carcinoma was made by the pathologist. No primary site could be found. A lymph fistula and swelling of the leg followed but subsided after 16 days. However, his pain continued and became progressively worse. X-ray therapy was given without relief, at another institution. He became progressively more emaciated and was readmitted under Dr Fraser's care on March 12, 1942. On March 31 an intrathecal alcohol injection was done but no relief from the pain was obtained. On April 3, section of the spinothalamic tract in the medulla was advised, because the original site of the malignant lesion had not been demonstrated, because a high thoracic cordotomy might prove ineffective later on, and because he had reached his limit of tolerance to opiates without relief of his pain.

Physical examination revealed emaciation, lymph edema of the genitals and left leg, ascites, and palpable glands in the rectal shelf. There were many red and white blood cells in every specimen of urine which, except for a slight trace of albumin, was otherwise negative. He had a hemoglobin of 62 per cent, a red blood cell count of 3,350, and a white blood cell count of 27 thousand. Lumbar punctures and studies of the cerebrospinal fluid were repeatedly negative as were x ray films of his bones. A 7 foot film of the chest showed a healed tuberculous lesion in the right upper lung field, a prominence of the left ventricle, and a widened aorta. A diagnosis of aortitis was made.

On April 8, a section of the spinothalamic tract in the right half of the medulla was carried out. The approach through the right side was similar to that described. There was some difficulty with hemor-

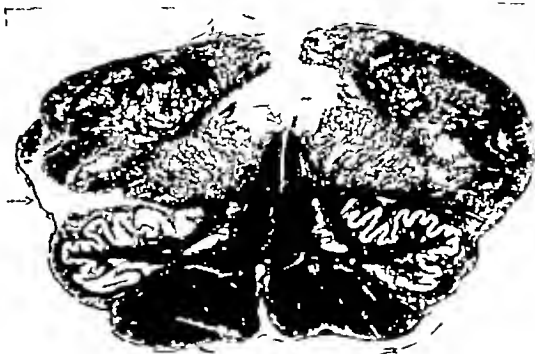


Fig 2 The medulla oblongata at the level of the inferior olivary nucleus. Arrow indicates site of the left lateral medullary tractotomy.

rhage in the latter part, however, because of the patient's lack of co-operation and he had to have $\frac{1}{4}$ grain morphine which was given subcutaneously. This quieted him and hemostasis was attained eventually. The dura was opened widely down to the arch of the atlas and the right cerebellar hemisphere, the vermis, the junction of the medulla and the cervical cord were well exposed. The posterior cerebellar artery came up into and looped twice upon itself in the wound. However, after a careful division of the arachnoidal adhesions which held it to the side of the medulla, it was possible to mobilize this artery sufficiently so that it could be held out of the field until after the medulla had been incised. The 10th and 11th nerves were identified at their points of origin and the area on the side of the medulla between the two nerves was wiped clean of a plexus of small veins. Because of the shape of the patient's posterior fossa, it was difficult to approach this lateral aspect of the medulla at right angles, and there was some doubt as to the success which would attend attempts at section of the tract. Furthermore, the patient, as a result of the morphine that he had had, now became so deeply anesthetized that only severe painful stimuli would awaken him. Fortunately, he responded to pain when the 5th nerve area was touched with the knife, and it was possible to identify that area by the aid of prickings with the cataract knife. Having located the lateral border of this area, a distance of 4 millimeters was measured off on the knife tip and marked with bone wax. The knife was inserted as nearly at right angles to the side of the medulla as possible immediately beside and above the superior filament of the 11th nerve. The knife had to enter the medulla at an angle of about 30 degrees but within that limit it was possible to make a circular cut within the substance of the medulla. It was impossible to determine success or failure of this intramedullary incision because the patient did not respond to pin prick on the opposite side of his body. For fear that all of the spinothalamic tract had not been cut, a curved, pointed Bard-Parker knife was inserted with the cutting edge up

t a depth of 5 millimeters into the same incision that had already been made. By pulling it out with the curve of the tip pointed posteriorly this completed the posterior part of the section. Because of previous experience in the last case and because of our inability to demonstrate any analgesic effect on account of the patient's general anesthetic condition, 5 millimeters were then measured off from the tip of the cataract knife and that instrument inserted into the wound. The blade was swung anteriorly so that it deepened the anterior half of the section. Again attempts were made to determine whether or not the patient was analgesic, but they failed. There was no bleeding from the medulla or anywhere else at this time and the wound was then closed in layers without drainage in the usual manner. The incisions in the medulla caused no change in blood pressure level. The patient's condition was satisfactory throughout the operation except for his neuro-operative anoxia. He was returned to bed in good condition immediately after the closure.

On April 1 symptoms of high testicular obstruction with fecal vomiting developed. This relieved by the use of the Miller Abbott tube and other appropriate measures. On April 4 the tube could be withdrawn. He was completely relieved of pain and required no opiates following the medullary tractotomy. As nearly as could be told he had anesthesia of pain and temperature on the left up to the level of 5th cervical spinal segment. His carotematomatosis and catarrhs advanced rapidly after the operation, however, and he died quietly on April 5, 1914, 14 days after the tractotomy.

Postmortem examination demonstrated the following poorly differentiated, rapidly growing squamous cell carcinoma of the urinary bladder with invasion of the rectum and regional lymph nodes and with metastases in the lumbar vertebrae, bilateral bronchopneumonia, bilateral hydrocoele and hydrocephalus, healed bilateral pitted cerebellar lateral medullary tractotomy, right postoperative and cerebellar hemorrhage which was probably operative.

At about the junction of the medulla and spinal cord, 1 centimeter below and just lateral to the right olivary body there was a small, slightly yellowish depression which measured 0.5 by 0.5 centimeter (Fig. 3). All the cranial nerves appeared to be undamaged except possibly the spinal portion of the spinal accessory. A horizontal section of the medulla revealed a soft grayish-yellow lesion in the lateral segment of the medulla which had a vertical extent of 5 centimeters. The central half of the right cerebellar hemisphere had a hemorrhage which had a diameter of 5 centimeters. It showed a moderate degree of encapsulation. No other abnormalities of the spinal cord, brain stem, or cerebellum were detected. There were no intracranial tumor metastases.

The brain stem and spinal cord were cut into blocks and sections were stained by the methods of Marchi, Weigert, and Nissl.

The operative lesion was situated at the level of the decussation of the pyramids in the lateral funiculus and lateral reticular substance (Fig. 4). It involved medially the 3 or 4 centimeter of the midline and had a vertical extent of approximately 0.5 centimeter. The lesion revealed several small hemorrhages 1.5 millimeter in diameter. The anatomical structures involved were the spinal tract and nuclei of the trigeminal nerve, the dorsal and ventral spinocerebellar tracts and the lateral spinothalamic tract on the right side. The lesion did not extend to the pyramidal or dorsal columns. There were large numbers of macrophages laden with fat and hemosiderin in the lesion.

There was a swelling degeneration of the dorsal spinocerebellar tract into the restiform body and of the ventral spinocerebellar tract into the upper level of the pons. The latter could not be traced into the superior cerebellar peduncle. The swelling degeneration of the lateral spinothalamic tract could be followed to the lower mesencephalon but was lost at that point. Throughout the entire length of the left column of Goll there was a degeneration of myelin. A definite evidence of descending degeneration was seen.

The leptomeninges over the medulla and cerebellum were moderately infiltrated with lymphocytes and a few plasma cells. Small collections of such cells were found in the spinal meninges of the cervical spinal cord.

Around the cerebellar hemorrhage there were large numbers of macrophages filled with hemosiderin, and increase in the number and size of the astrocytes in the adjacent tissue.

Again some of the medially placed fibers of the lateral spinothalamic tract carrying pain and temperature for the arm and back were escaped section, thus accounting for the absence of hypalgesia above the level of the 4th dorsal segment. Unlike the first case the lesion in the medulla was much more extensive both horizontally and vertically because of the hemorrhage which probably resulted from section of a small vessel. The hemorrhage in the cerebellum, judging from the amount of organization which had occurred, probably happened at the time of operation when the cerebellum was manipulated to afford a better exposure.

The meningeal reaction was probably related to the operation and could have been caused by a slight localized post-operative infection.

CASE 3. A woman of 5 years referred by Dr. Charles W. Meyers of Indianapolis. First seen by one of the Box and Hays on April 3, 1911. She had complained of pain in her left leg for the previous 6 months. She had been ill

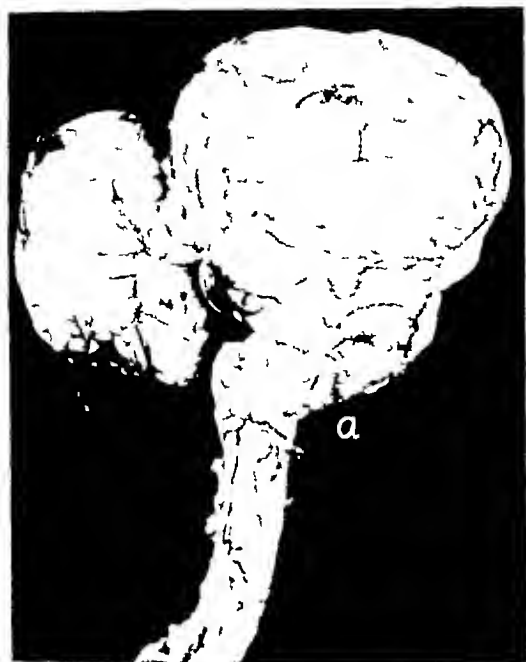


Fig 3 The cerebellum, medulla and upper end of the spinal cord. a, Site of right lateral medullary tractotomy.

until February or March, 1941, at which time she consulted her physician about some vaginal discharge. She was told that she had a malignant tumor of the uterine cervix and was treated with radium and by x ray. After a short period of improvement the pain recurred in both thighs and was accompanied by lower abdominal discomfort. In November, 1941, both ovaries and the body of the uterus were removed, the cervix being left in place. This gave her no relief from her pain so an intrathecal injection of alcohol was attempted. This too, was unsuccessful, and, following it, she developed severe pain involving the entire left leg, numbness of both feet and ankles and fecal incontinence. She gradually lost weight and strength, had to use large amounts of dilaudid to control her pain, and had been bedridden for 5 months previous to her admission to the Boston City Hospital. She developed a sensitivity to morphine and recently had had frequent episodes of nausea and vomiting accompanying her pain. Physical and neurological examinations were negative except for cachexia, a healed suprapubic scar, generalized asthenia, pin point pupils, anesthesia of the left labia majora, hypesthesia of her left foot and ankle, and a diminished knee and absent ankle jerk on this side. Her blood pressure was 110/90. Her urine was full of red and white blood cells with a slight trace of albumin. She had a hemoglobin of 64 per cent, a red blood cell count of 3.6, and a white blood cell count of 15 thousand. Her nonprotein nitrogen was 27.



Fig 4 The medulla oblongata at the level of the decussation of the pyramidal tracts. Note the extensive degeneration of the myelinated fibers lying between the spinal nucleus of the trigeminal nerve and the pyramidal tract on the right.

Because of the possibility of high spinal metastases, a section of both spinothalamic tracts in the medulla, each side being done separately and with an interval between, was advised. The tract on the right side was sectioned on April 27, 1942, through a right-sided approach as described. The dura was widely opened in such a way as to expose the right cerebellar hemisphere, the vermis, and the junction of the medulla and the spinal cord. The right cerebellar hemisphere was freed from a few filmy attachments to the medulla and turned upward and medially, thus exposing the right side of the medulla. The calamus, the 10th and 11th nerves and their points of origin from the side of the medulla were identified. The 12th nerve could be easily seen in front of these others. The surface of the medulla next to the exit of the uppermost filaments of the 11th nerve was covered by a plexus of small veins. These were gradually brushed to one side until a cleared area was obtained. None of the larger vessels interfered in any way with the field. Five millimeters were measured from the tip of a cataract knife and marked with bone wax and the knife inserted into the medulla at what was believed to be the proper point. This produced pain in the patient's lower jaw, however, so it was evident that the insertion was too far posterior. A point more anterior was chosen and the knife inserted to the depth of 4 millimeters without causing pain. It was then swung in an arc forward and backward, the extreme backward arc causing pain in the patient's nose. The patient was then tested for analgesia with a pin, and it was found that she was analgesic up to

the level of the lower angle of the scapula. The knife was again inserted but this time to a depth of 5 millimeters and again swung in an arc and again caused pain in the nose at the same place. Testing demonstrated that there had been slight rise in the analgesic level perhaps the middle of the scapula. 51 millimeters are now measured on the cataract knife tip and marked with bone wax and then the knife as inserted for a 3d time. Following this the anesthetic level rose to about the level of the shoulder. Pain was again caused in the nose at the posterior extremity of the arc, but no pain as caused in the larynx. There was small amount of bleeding following this from surface vessels which had been divided. This stopped very promptly leaving, however, certain amount of clotted blood which surrounded the filaments of the sixth nerve. This could not be removed by wiping, suction, or irrigation so, rather than endanger the sixth nerve it was left in place. The wound was then closed in layers without drainage and the patient was returned to bed in excellent condition. During the operation at the time the cistern was drained the patient's blood pressure dropped from 35/80 to 20/70. However, it rose again immediately thereafter and 10 min later the time the location of the medulla was back to 40/80. Following this incision and for the next fifteen minutes, it was 60/90. Thereafter it fell in the course of another 10 min to 14/50 and in another 5 minutes to 5/55, where it remained until the end of the operation. The anesthesia was entirely satisfactory and the patient was able to co-operate throughout the operation.

Her convalescence was uneventful, and on May 4 it could be demonstrated that she had no pain sensation on the left side of the body below the 10th rib. She still required dilaudin and still complained of pain in her abdomen and right leg, however. On May 8, 1933, the second operation was performed and the apnoealamic tract cut in the left half of the medulla by technique similar to that described. The dura was reopened, there being little difficulty from bleeding and the left cerebellar hemisphere was exposed. The cistern had not healed and the cerebrospinal fluid over the medulla was lying under the dura and outside the cisternal sac. This was drained off and the left cerebellar tonsil was lifted out of the remains of the foramen magnum, and the left lateral aspect of the medulla was exposed. The patient had been somewhat restless up to this time and now her restlessness brought about a condition in which she was causing increased bleeding and difficulty in the operation so she had to be given 1/2 grain of pantopon. This quieted her markedly—in fact she became unresponsive to peripheral stimulation. Even though her active co-operation was desirable it was thought inadvisable to wait for the effects of the medication to wear off. An arc on the lateral aspect of the medulla immediately superior to the upper filament of the 11th cranial nerve therefore prepared. A plexus of small veins lying in the pia in this region had to be scraped away and

there was some difficulty in rotating the medulla sufficiently so that a straight knife could be used to make the medullary incision. Despite these difficulties, the original medullary incision was made with a straight cataract knife which was inserted to the depth of 5 millimeters and turned in an arc. As there was some doubt as to the efficacy of this incision, a fine hooked knife was then inserted for a distance of 6 millimeters, its point being swung in an arc also. There was no bleeding from the medulla, and no effects on the patient other than rise of pulse rate from 60 to 80. The dura was closed. Because of fall in the patient's blood pressure blood transfusion was started and the rest of the operation was postponed for short time until the transfusion was ended—matter of half hour or so. Her blood pressure then rose and the closure was completed. The patient was in fair condition at the end of the operation and was returned to her bed at once.

On May 12 she appeared to have no pain on either side of her body from the clavicles down and sensation on her face appeared limited. Opium was no longer required. Later on May 23, it appeared though she did have some pain on the right side of her body although she refused to describe her sensations as being painful. Empirin compound given every 4 hours in 3 or 4 grain doses kept her comfortable. After period during which the infection in her bladder caused trouble she developed pain in the region of her shoulders and head. Shaking tremor in gradually increasing doses was commenced on June 1 and was successful in controlling this pain until her death. On June 26 the midpoint of the cross bow opercular incision became necrotic and she began to slip downhill rapidly. She developed vesiculointestinal fistula. A week before her death intestinal fistula broke open in the abdominal scar. She died quietly and comfortably on August 9, 1932. This was 5 days after the first operation and 3 days after the second.

The findings at post-mortem examination were as follows: carcinoma of the cervix with spread to the lymph nodes locally the small and large bowel, the rectum, the bladder and the uterus. Intestinal tract connecting the rectum and small bowel with the uterus, the bladder and the anterior abdominal wall. Structure of left rectum with hydrosarcoma and hydronephrosis, bronchitis, cholecystitis, cholelithiasis and infectious biliary carcinoma and bilateral metastatic carcinoma. Post-operative

All cranial nerves appeared to be intact save for few filaments of the right vagus which were soft and gray. On the right lateral surface of the medulla, centimeters below the olive and just posterior to the retro-olivary sulcus there was a small depressed area which softer than the surrounding tissue. This probably represented the site of the right tractotomy. A visible evidence of the left tractotomy which had been performed was present externally.



Fig 5 Horizontal section through the medulla showing the sites of the bilateral tractotomy in Case 3

Upon section of the medulla in the horizontal plane yellow-gray softened areas were found bilaterally in the lateral reticular zone. The left column of Goll was gray throughout its length in the spinal cord. No sign of tumor metastases was noticed. The medulla was divided into blocks and representative blocks were taken also from the spinal cord, pons, midbrain and thalamus. Sections from all blocks were prepared by the Weigert and Nissl methods.

The lesions caused by the operations were situated in the retrolaryngeal regions bilaterally (Fig 5). That on the right side extended about 0.3 centimeter posterior to the olive and medially to a depth of 0.7 centimeter. The structures which were destroyed or interrupted were the lateral spinothalamic tract except for the medial fibers, the ventral spinocerebellar tract, the external arcuate fibers, a few fibers and cells of the spinal tract and nucleus of the 5th nerve and part of the dorsal accessory olive. There was no definite ascending or descending degeneration.

The lesion on the left side was smaller than the right one. It extended medially to a depth of 0.5 to 0.6 centimeter and had an anteroposterior diameter of 0.2 centimeter. It had destroyed or interrupted all the spinothalamic tract, except the most medially placed fibers, the ventral spinocerebellar tract, and a few fibers and cells of the spinal tract and nucleus of the trigeminal nerve. In both of these lesions only a few myelinated tracts were present. The other nerve fibers had degenerated and been replaced by macrophages filled with fat. There was a foreign body giant cell in the left lesion. The left column of Goll and the left dorsal and ventral roots of the lumbar cord had degenerated (Fig 6). The anterior horn cells in the 5th lumbar segment were rounded and showed central chromatolysis—"axonal reaction."

Neither of the incisions was deep enough to sever all the most medially placed fibers of the



Fig 6 Horizontal section through the cervical spinal cord. Note the degeneration of the column of Goll on the right. This was ascending in type and secondary to lumbosacral nerve root damage caused by the intrathecal injection of alcohol.

lateral spinothalamic tracts more escaped on the left than on the right. This accounts for the preservation of pain and temperature senses in the neck. The degeneration of the dorsal and ventral roots of the lumbar cord is believed to have occurred either because of the intrathecal injection of alcohol or the vertebral metastases. The intramedullary extensions of these lumbar root fibers, the column of Goll, had secondarily degenerated.

OBSERVATIONS FROM STUDY

A study of these 3 cases justifies certain conclusions relative to the danger and technique of the operation, the results to be expected from it, and its place among neurosurgical procedures for obtaining relief from pain.

The danger of the operation done under proper conditions and by one familiar with the field appears to be minimal. The patients reported herein were the worst possible type of surgical risk, nevertheless they had little if any postoperative reaction. The operation should, if at all possible, be done under local anesthesia and with the patient's head 45 degrees higher than his feet. Enough bone should be removed to allow for easy mobilization of the cerebellar hemisphere and posterior cerebellar artery and should include that in the midline of the occiput and the posterior half of the foramen magnum.

The best that can be expected in terms of analgesia from this operation is relief of pain from the level of the clavicle downward. This procedure will not produce analgesia in the shoulders, arms, neck or head. High cervical spinothalamic cordotomy, section of posterior spinal roots, and division of certain cranial nerves are necessary if these areas are to be included in the analgesic area. We see no reason why this medullary tractotomy cannot be combined with section of any of the appropriate cranial nerves in the posterior fossa, however keeping in mind that a bilateral posterior fossa craniotomy has to be made in that case. From the clinical and technical point of view medullary tractotomy whether unilateral or bilateral will prove ideal in those cases in which a thoracic cordotomy can be expected to be ineffective because of the high level of trunk pain or the possibility of high lung or spine metastases. If however the object of the operation is to divide the cervical and brachial fibers in the spinothalamic tract, then the operation has little to recommend it over a high cervical cordotomy combined with section of posterior roots in the upper cervical region. At least in all our cases we were unsuccessful in producing analgesia of the neck and shoulder.

Although anatomically the most favorable site for section of the spinothalamic tract in the medulla is at the inferior pole of the olive from an operative technical point of view the location of the uppermost radicle of the 11th cranial nerve will determine the site in the vertical plane while the production of pain in the 5th nerve by prodding the surface of the medulla provided the patient is conscious, will determine the horizontal site of insertion of the knife. Judging from this experience 3 millimeters is a safe depth for the medullary incision although 6 millimeters, if it can be used, is probably preferable. Anterior and posterior limits of the swing of the knife are determined by pain in the face on the one hand and in the throat on the other. Bilateral section if separated by a short interval, appears to be safe. There is still some question as to the optimal level within the medulla at which the section should be made. In the first case the incision was placed about 0.5

centimeter above the level of the inferior pole of the olive. In the 2d case it was at the junction of the medulla and cervical cord. In the 3d case the incisions were about 0.3 centimeter below the inferior pole of the olive. The level should be determined by the accessibility of the lateral spinothalamic tract the prominence of landmarks, and the proximity of other important neurological structures and blood vessels.

In consideration of these points we propose that the preferred operative site be the inferior pole of the olive because (a) most of the high cervical secondary neurones for pain and temperature should have decussated by then, (b) the olive and retro-olivary sulcus are good landmarks, (c) the 9th and 10th cranial nerves, restiform body and pyramidal tract decussation are sufficiently remote to avoid injury.

We agree with Grant and Weinberger, J. C. White and Schwartz and O'Leary that tractotomy is a feasible procedure and can be performed even bilaterally without danger to life. This is contrary to the old teaching that the medulla is a vital organ the slightest injury of which will be fatal. It is well to remember that most nuclear masses, not only in the spinal cord but also in the brain stem, are represented for a considerable distance vertically and that a horizontally placed surgical incision will damage relatively few nerve cells. There is some danger of hemorrhage from severance of a small intramedullary vessel.

Only 1 of the 3 cases was suitable for studying the central course of the spinothalamic fibers by the Marchi technique. Other investigators (Goldstein, Foerster, Walker for example) have succeeded in following this tract to its central termination in the posterolateral nucleus of the thalamus. Our failure to trace it above the pons was probably because of the fault of the Marchi technique used in our laboratory.

SUMMARY AND CONCLUSIONS

The cases of 3 patients in whom a unilateral section of the spinothalamic tract, and of 1 in whom a bilateral section of the spinothalamic tract was carried out in the medulla, are discussed in detail.

All patients survived their respective operations.

In every instance the operation was followed by analgesia extending downward from about the level of the 2d thoracic dermatome on the appropriate contralateral side of the body. No analgesia was produced above the clavicles.

Postmortem studies of the 3 medullas demonstrated that it is impossible to cut the cervical portion of this tract in the medulla without causing crippling and unjustifiable damage.

Clinically if the operation is done under local anesthesia the most satisfactory point of entry of the knife is at the level of the uppermost filament of the 11th cranial nerve. Its location in the anteroposterior direction will be determined by the production of pain in the face. The point of entry is just anterior

to this point. The depth of the incision must not be less than 3 millimeters, but in our experience cannot exceed 6 millimeters because of involvement of the 10th cranial nucleus anteriorly and the tract of the 5th nerve posteriorly.

Anatomically the ideal point of section is at the inferior pole of the olive.

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THE USE OF PECTIN AND OTHER AGENTS TO PREVENT SHOCK

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PECTIN is a colloid carbohydrate obtained from vegetables and fruits¹. It is better known to the profession as a substance used for oral therapy in certain intestinal ailments.

The use of pectin solution has been advocated as a blood and plasma substitute in the treatment of shock. (9) It leaves the blood stream slowly due to its high molecular weight. It can be made into solution isotonic with blood exerting an osmotic pressure and possessing a viscosity similar to that of whole blood (15) It does not have any cumulative effect and is retained in the circulation for some time—4 to 24 hours (2) being excreted unchanged in the urine. It is nonantigenic and innocuous. Pectin solution can be obtained and processed more economically than can plasma.

In traumatic shock when there is a loss of plasma at the site of injury or systemically due to increased permeability of the capillaries (3, 4, 12) the use of crystalloid solutions such as isotonic saline and glucose is of transitory value (1, 11) in fact they may be harmful if given in large amounts, because they tend to leave the vessels quickly (1, 3, 4) carrying protein along with the fluid producing tissue edema, and lowering the already depleted plasma volume to a critical level (7, 10).

Blood and plasma, when available are the most suitable fluids in the treatment of shock therefore the use of pectin or similar substances would be considered chiefly in the absence of sufficient quantities of blood or plasma. The efficacy of the pectin solution depends somewhat on the method of preparation and sterilization. The solutions that we used in our experiments were clear and free of pyrogen.

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The pectin used in this experiment was pure grapefruit pectin.

INTRAVENOUS USE IN ANIMALS

Exclusive of hemorrhage the exposure and massage of intestines has been considered one of the best methods for producing experimental shock (16). We decided first to investigate the effectiveness of pectin in the prophylactic and active treatment of shock in animals (dogs). Although hemorrhage is an effective way of producing shock we thought results would be more significant if we did not utilize hemorrhage as the sole factor in the pathogenesis of shock. Early in the massage there is an edema of the intestines with a consequent increase in volume. However later the edema disappears plasma-like fluid exudes from the surface of the bowel in sufficient amount to contribute to the fall of blood pressure (4, 5). In these animals, pulling on the stomach the abdominal side of the diaphragm, the duodenum the upper parietal peritoneum, or putting ice cubes in the upper abdominal cavity did not cause a sufficiently constant fall in blood pressure to utilize such procedures in our experiments.

EXPERIMENT (Control vs. physiologic saline). The experiments are performed on healthy dogs, 15 to 20 pounds in weight. Either an ether anesthetic, and the nervous system maintained by tracheal intubation. The arterial blood pressure is recorded by mercury manometer attached to a cannula containing 5 per cent sodium chloride solution and inserted in the femoral artery. The blood pressure changes were recorded every 5 minutes. The intestines are brought out through median abdominal incision, and traction is exerted on the mesentery while the loops of bowel are constantly and severely massaged until blood pressure fall of 5 millimeters of mercury was reached and maintained for 10 minutes. The operative error as much as possible manipulation was done by one person. Manual of intestine was squeezed 5 times per minute.

Controls: Seven healthy dogs are shocked by intestinal manipulation and the blood pressure recorded. It will be noted (Fig. 1) that it required a massage of 54 minutes of constant and severe massage to lower the blood pressure 50 millimeters of mercury. There was an immediate fall of blood pressure of 8 millimeters of mercury within

minutes. After this, the fall in blood pressure became more gradual, until the shock level was reached, then there was another sharp drop. The animals were killed with an overdose of ether.

Effect of physiologic saline. Eight dogs were given 300 cubic centimeters of physiologic saline solution before the manipulation of the intestines and 200 cubic centimeters during the trauma. The blood pressure was recorded every 5 minutes.

There was an immediate fall in blood pressure of 10 millimeters of mercury within the first 10 minutes of manipulation as noted in the controls. In every animal the blood pressure was sustained for some time, the average being 10 minutes, after which the blood pressure began to fall again. It required an average of 62 minutes of intestinal trauma to lower the blood pressure 50 millimeters of mercury, thus physiologic saline solution delayed the 50 millimeters of mercury fall in blood pressure only 8 minutes longer than those which received no medication (Fig. 1).

EXPERIMENT 2 (One per cent pectin solution). In this group 10 dogs were used and 1 per cent pectin solution was injected, 300 cubic centimeters before manipulation of intestines and 200 cubic centimeters during the trauma.

There was no immediate fall of blood pressure in these dogs as in those used as controls or those that received physiologic saline solution. The blood pressure remained at normal level for a period of 20 minutes before it began to fall. This group of 10 dogs required 82 minutes of intestinal manipulation to lower the blood pressure 50 millimeters of mercury. This is a delay of 28 minutes over the controls and 20 minutes over the animals which received physiologic saline. Obviously, the 1 per cent pectin solution was responsible for delaying the occurrence of shock.

EXPERIMENT 3 (One per cent pectin plus physiologic saline). This series of animals received 500 cubic centimeters of a solution consisting of 250 cubic centimeters of physiologic saline and 250 cubic centimeters of 1 per cent pectin solution, administered in the same manner as in the previous experiments. There was an immediate fall in blood pressure, but it required 81 minutes of intestinal manipulation to lower the blood pressure 50 millimeters of mercury. This fall occurred at about the same rate as in those animals which received the 1 per cent pectin solution.

EXPERIMENT 4 (Blood serum). In this group of 6 dogs, 250 cubic centimeters of serum was injected at the same time that intestinal trauma was started. The serum was prepared from defibrinated dog's blood by whipping it with a very flexible test tube brush and centrifuging it for 35 minutes.

There was an immediate but slight fall in blood pressure within the first 10 minutes of intestinal manipulation. It required 113 minutes of manipulation to lower the blood pressure 50 millimeters of mercury, or 59 minutes longer than the controls (Fig. 1).

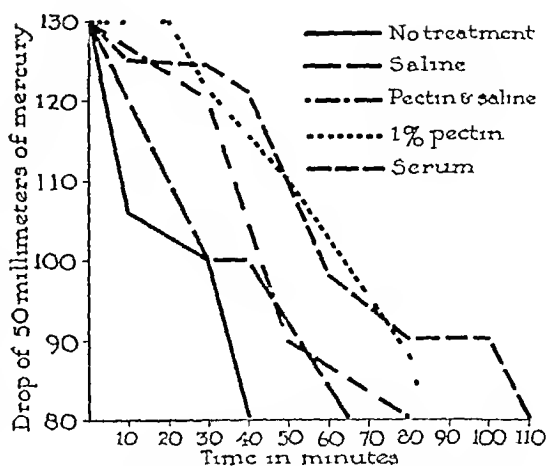


Fig. 1. Type and fall of blood pressure during manipulation of the intestine with and without treatment.

These results indicate that dogs to which pectin solution is given are more resistant to shock than are dogs to which no treatment or physiologic saline is given while the intestines are massaged. However, the pectin was not so effective as serum in preventing shock.

EXPERIMENT 5 (Other therapeutic agents). Other therapeutic agents were used to determine their benefit on the experimental animal in preventing the onset of shock.

a Adrenal cortical extract. Five dogs were used. Each animal received subcutaneously 0.5 cubic centimeter of adrenal cortical extract per pound of body weight in 5 divided doses, each dose being 30 minutes apart. Ninety minutes after the initial dose was given, intestinal manipulation was started. There was no immediate fall in the blood pressure as occurred in all of the previous experiments (with the exception of those animals which received 1 per cent pectin). It required 89 minutes to lower the blood pressure 50 millimeters of mercury. Adrenal cortical extract was surpassed only by serum in delaying the 50 millimeter fall of blood pressure (Table II).

b Adrenal cortical extract plus saline. Seven dogs were used. They received 500 cubic centi-

TABLE I—TIME REQUIRED TO LOWER BLOOD PRESSURE 50 MM OF MERCURY BY INTESTINAL MANIPULATION AND WITH CERTAIN TYPES OF THERAPY

Solution	Time—minutes
Controls (no medication)	54
Saline, 500 c c	62
Pectin, 1 per cent, 500 c c	82
Pectin, 1 per cent, 250 c c plus 250 c c saline	81
Serum, 250 c c	113

TABLE II.—COMPARISON OF DROP IN BLOOD PRESSURE WITH VARIOUS THERAPEUTIC AGENTS DURING MANIPULATION OF THE INTESTINE

Substances	Drop in blood pressure —mm. Hg—	
	in 10 minutes manipulation	in 30 minutes manipulation
Controls		
Physiologic saline, 500 c.c.	4	35
Pectin solution, 500 c.c., per cent	22	45
Pectin, 50 c.c., per cent plus 30		70
c.c. physiologic saline	26	45
Serum, 30 c.	24	34
Adrenal cortical extract	70	84
Adrenal cortical extract plus physiologic saline (500)	4	35
Adrenal cortical extract plus per cent pectin (500 c.c.)	8	
Adrenal cortical extract plus per cent pectin (30) and physiologic saline (30 c.c.)		30
Adrenal cortical extract plus serum (30 c.c.)	4	4

It is evident that pectin, serum, and adrenal cortical extract inhibit the fall in blood pressure.

50 millimeters of mercury. This is 8 minutes longer than was required to lower the blood pressure to a similar level in the animals which received 1 per cent pectin and physiologic saline solution without adrenal cortical extract.

c. Adrenal cortical extract plus serum. Seven dogs received 30 cubic centimeters of serum to which had been added 0.5 cubic centimeters of adrenal cortical extract per pound of body weight. This solution was administered intravenously before intestinal manipulation was started. The normal blood pressure was maintained for 30 minutes before drop was noted. The decline in blood pressure from that point on was steady but gradual. It is apparent that the adrenal cortical extract delayed the 50 millimeter fall in blood pressure 30 minutes longer than in those dogs which received serum alone.

Experiment 6. In this group of experiments various agents were used in attempt to combat shock (T ble II) induced by massage of the intestine over a period of 60 minutes. Four to 8 animals were used in each group. As noted in T ble II the average fall in blood pressure in 40 minutes of manipulation in control animals was 4 millimeters and in 60 minutes manipulation 35 millimeters, representing fall similar to the controls in Experiment 1 (T ble I). The experiments summarized in Table II reveal that 3 of the 4 substances used (1 pectin, adrenal cortical extract and blood serum) delay the development of shock when intestinal manipulation is carried out. There is not great deal of difference in the protective effect of the 3 substances although a mixture of adrenal cortical extract and serum appears to be more effective than any of the others. As in other groups of experiments saline itself offers very little protective effect. In fact, when combined with other agents, it actually appeared to interfere with their protective action. We have no doubt that if serum were used in larger quantities, it would be proved more effective than any of the agents used.

INTRAVENOUS USE IN MAN

A solution of 0.75 per cent of pectin was used clinically in cases in which saline blood or plasma would have been indicated. On the average the solution was given at the rate of 500 cubic centimeters per hour the largest quantity administered to one patient was 1500 cubic centimeters. The solution has been given clinically to 75 patients a few had repeated infusions and 1 patient had a history of bronchial asthma. Nine patients received the pectin during operations and one while in shock due to hemorrhage. The clinical results are best illustrated in the following cases

TABLE III—PLASMA VOLUME CHANGES FOLLOWING INJECTION OF PECTIN AND SALINE SOLUTION

Patient	Initial plasma volume—c.c.	Amount injected—c.c.	Increase in plasma vol 4 hrs after infusion—c.c.	Hematocrit before and after
Pectin				
Mr A F	2755	500	505	38-37
Mrs M L	3260	500	500	37-37
Mr F B	250	500	650	36-36
Mrs E N	2860	500	510	37-35
Mrs H D	3500	500	500	38-36
Mr H C	3800	500	575	37-38
Mr C K	2025	500	537	37-37
Mrs H M	2125	500	500	36-38
Mrs L N	2900	500	600	36-38
Saline				
Mrs H B	2875	500	150	38-38
Mrs M C	2815	500	170	37-37

Average increase in plasma volume after pectin 542 c.c. No change in hematocrit reading

Average increase in plasma volume after saline 160 c.c. No change in hematocrit reading

CASE 1 S G, a white male, weighing 150 pounds, was admitted to the emergency room of St Elizabeth's Hospital, bleeding profusely from a stab wound in his right thigh. He had a tourniquet on his upper thigh, and he was cold, clammy, wet with perspiration, ashen-gray in color, thirsty, and his breathing was shallow. The pulse was 120 and of small volume, the blood pressure was 86/40. The diagnosis of shock was obvious. Unfortunately, no blood or plasma was immediately available. We decided to give him pectin solution while obtaining blood. He was given 1/6 grain morphine sulfate. The bleeding vessels were ligated and two sutures were used to approximate the skin. A prophylactic dose of tetanus antitoxin was administered. He was given 1500 cubic centimeters of 0.75 per cent pectin intravenously over a period of 2 1/2 hours. His blood pressure rose to 124/76, the pulse rate was 72, the dizziness disappeared and he felt well. He went home the next day. No reaction was sustained.

To determine what effect pectin solution would have on the blood pressure during an operation, we gave the solution to the following patients:

CASE 2 T W, a white male, weighing 165 pounds, was admitted to St Elizabeth's Hospital, feeling nauseated and with a history of pain in the right side of his abdomen of 2 days' duration. His red and white cell counts were 4,800,000 and 7,800, respectively, hemoglobin, 85 per cent, his temperature was 99.2 degrees F, pulse rate, 84, and blood

TABLE IV—BLOOD PRESSURE AND PULSE RATE CHANGES FOLLOWING INJECTION OF PECTIN

Patient	Average blood pressure before and after infusion		Average pulse rate before and after infusion	
Pectin				
Mr H T	122/70	126/80	72	76
Mr A L	122/70	122/70	72	76
Mrs B S	170/90	170/90	72	72
Mrs A C	120/70	126/80	80	84
Mrs E H	130/70	134/80	84	88
Mrs A P	130/70	136/80	92	96
Mr A F	160/80	170/80	72	76
Mrs M L	124/80	128/80	76	80
Mr F B	122/80	126/80	72	76
Mrs E N	90/60	110/70	96	84
Mrs H D	122/70	126/80	76	76
Mr H C	124/70	126/80	72	76
Mr C K	130/70	136/80	72	76
Mrs H M	110/70	110/70	72	72
Mrs L N	110/70	120/80	72	76
Saline				
Mrs H B	122/70	122/70	76	76
Mrs M C	120/80	120/80	72	72

Average increase in blood pressure after pectin: systolic = 5 mm. Hg, diastolic = 6 mm. Hg. Average increase in pulse rate = 2 per minute. No increase in blood pressure or pulse rate after saline.

pressure 112/80. A diagnosis of recurrent appendicitis was made. He received 500 cubic centimeters of 0.75 per cent pectin solution during and after the operation. His blood pressure 2 hours after the operation was 120/80, he did not have any reaction.

CASE 3 J B, a white male, 25 years old, weighing 170 pounds, was admitted to St Elizabeth's Hospital with symptoms of acute appendicitis of 12 hours' duration. His temperature was 99.6 degrees F, pulse rate, 92, and blood pressure 110/80. He had red and white cell counts of 5,500,000 and 12,000, respectively, with a differential count of 88 per cent polymorphonuclear cells and 22 per cent small lymphocytes. The hemoglobin was 95 per cent. He received 500 cubic centimeters of 0.75 per cent pectin during the operation and 500 cubic centimeters after the operation in 1 hour and 15 minutes. There was no reaction.

CASE 4 D W, a white boy, 11 years old, weighing 108 pounds, was admitted to St Elizabeth's Hospital, with a diagnosis of acute appendicitis. The laboratory examination revealed hemoglobin 85 per cent, red cell count of 4,500,000, white cells 16,150, with a differential count of 85 per cent polymorphonuclear cells and 15 per cent small lymphocytes. The blood pressure and pulse rate before operation was 110/80 and 88. He received 350 cubic centimeters of 0.75 per cent pectin solu-

tion. The blood pressure rose to 20/80. No reaction noted.

CASE 5. Mrs. L. McE., a white female, born, weighing 165 pounds, complained of gastric distress after meals. Previous x-ray examination revealed a nonconcentrating gall bladder containing stones. The laboratory examination revealed: leucosis index of 10, red cell count of 3,800,000, white cells 5,500, polymorphonuclear 80 per cent, 20 per cent small lymphocytes, hemoglobin 80 per cent. The blood pressure before operation was 230/80. Her gall bladder was removed under cyclopropane anesthesia. She received 500 cubic centimeters of 0.75 per cent pectin during the operation, and 500 cubic centimeters after she returned to her room. The blood pressure 4 hours after the operation was 50/80. There was no immediate or late reaction.

PLASMA VOLUME STUDIES

In 9 normal individuals the plasma volume was computed according to the Evans blue dye method (6, 8, 13) using 5 cubic centimeters of 0.7 per cent solution sterilized by autoclaving. Computation was made with the aid of a photoelectric colorimeter. The plasma volume was determined before and 4 hours after the administration of 500 cubic centimeters of 0.75 per cent pectin solution.

(Tables III and IV.) The average increase in plasma volume was 54.9 cubic centimeters. The plasma volume in 3 cases (Mr. H. C., Mrs. L. H., Mr. F. B.) still remained above the initial plasma volume 20 hours after the infusion (50 c.c., 70 c.c., 80 c.c. above, respectively).

Two patients (Mrs. H. B., Mrs. M. C.) received 500 cubic centimeters of physiologic saline solution and the plasma volume determined in the same manner as the patients who received pectin. In these individuals the plasma volume 4 hours after the infusion was 150 cubic centimeters and 170 cubic centimeters above the initial plasma volume. Although the amount of fluid injected was the same as that given to patients receiving pectin the plasma volume increase in the same interval was much less than the quantity administered. (Table III.) These findings correspond with the results obtained by Jacobson and Smyth (2) who found that after the infusion of 1000 cubic centimeters of physiologic saline solution, the plasma volume was definitely less than the amount given (a gain of only 350 cubic centimeters). In contrast they did observe that pectin solution is retained in the

circulation from 4 to 5 hours, and in some of their cases the plasma volume was still above the original, 24 hours after the infusion. We did not encounter any reactions that we could have attributed to the blue dye or the combination of the dye and the pectin solution.

The hematocrit readings in these patients remained about the same level (37-36).

SUMMARY AND CONCLUSIONS

Pectin is an economical substance for the preparation of colloidal solutions. It is non-antigenic, nontoxic and is retained in the circulation longer than solutions of crystalloids.

It prevents the onset of shock in experimental animals for a longer time than when physiologic saline or isotonic glucose solutions are used alone.

It sustains the blood pressure well as shown clinically in a patient in shock from hemorrhage and in those who were undergoing operations.

The results obtained in these experiments indicate that pectin solutions may be used as a substitute for plasma or whole blood when these substances are not available.

In another set of experiments in which the fall of blood pressure was observed following 60 minutes manipulation of intestines, various agents including pectin, adrenal cortical extract, serum, and physiologic saline (Table II) were used to see if they would inhibit the development of shock. Each of the first 3 mentioned exerted a protective influence and to about an equal degree. We have no doubt that in larger doses serum would have been more effective than was any of the other solutions.

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STUDIES IN THE LYMPHATICS OF THE FEMALE URINARY BLADDER

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THE importance of the rôle played by the lymphatic system in medical and surgical diseases has now become well established. A thorough knowledge of the lymphatic circulation in the various organs of the body is often essential in translating the significance of pathologic changes. After a review of the medical literature in dealing modern textbooks on urology, one is convinced that little attention has been paid to the lymphatics of the human bladder. No attempt has been made to correlate the laboratory studies with urologic and pathologic problems. It is the hope in reporting these studies that the clinician's attention will be called to the importance of considering the lymphatics when he has occasion either to operate upon or to treat diseases of the bladder.

There is general agreement in the literature as to where the lymph collectors go after leaving the bladder wall. In fact, the location of the primary lymph nodes appears to have been the main object of most of the investigators. The location of these nodes, as reported by Parler, has been added to the composite drawings reported here merely to complete the lymphatic picture (Fig. 1). The purpose of this paper is to describe the lymphatics of the bladder itself. The posterior abdominal lymph nodes have received only secondary attention in this present study. From an extensive study of the lymphatics of a large group of human bladders *in situ*, it is believed that this knowledge may have clinical significance.

The lymphatics of the adult human bladder are difficult to inject, for this reason infant cadavers were used exclusively. Dilute India ink was introduced into the bladder wall with a fine hypodermic needle. When a collecting lymph vessel became visualized the collector was followed by massaging or reinjecting until it ended either in another lymph vessel or a lymph node. This was carried out from every possible location of the bladder. Camera lucida sketches were made in approximately a dozen cases by the medical artist while the work was in progress. In a similar group of cases, the injected bladders were removed and prepared for study. Some were cleared by the Spaltcholz technique, and all were preserved for careful study by the artist. By means of semidiagrammatic, composite drawings, it was possible to illustrate the important findings as they were interpreted.

GENERAL DESCRIPTION OF THE LYMPHATICS OF THE BLADDER

Lymph vessels originate in lymph capillary networks. When they are not supplied with valves their form remains relatively cylindrical. Usually after several larger cylindrical vessels unite the terminal collector is seen to contain valves. The form of the vessel then becomes beaded, that is, alternately constricted and dilated. As the beaded collector becomes larger the number of valves diminishes, that is, the distance between the valves becomes greater as the diameter of the vessel becomes larger. The courses of the lymph vessels are particularly tortuous in the blad-

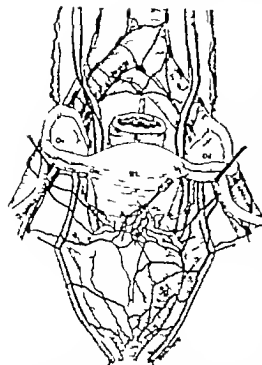


Fig. 1. Regional lymph collectors and nodes of the bladder. Note the close relation of the main collectors with the uterine, vaginal and hypogastric vessels as well as the ureter and cervix of the uterus.

der. This is due in part to the elasticity of a large part of the organ.

Attempts to inject the mucosa in many human and animal bladders were without success. Anesthetized dogs were used in an effort to inject the material into the mucosa so that a lymphatic network could be verified. A definite lymphatic network in the mucosa could not be demonstrated. Perhaps there are lymph spaces that open directly into the adventitia of the submucosa. In the submucosa, the network could be demonstrated. The lymphatic ducts began here and ran as small collectors in a staircase fashion immediately to the external surface and joined the collectors running along in the adventitia covering the bladder. In the area which is covered by the peritoneum the collectors received lymphatic capillaries from this overlying membrane.

The direction of the lymph stream is normally determined by the valves within the

lymph vessel. In those collectors that have no valves, retrograde flow may take place if the main channel becomes obstructed. It is even possible to produce retrograde flow for a short distance in the beaded collectors if the obstruction is complete and persists for a long time in the live experimental animal. A heavy metal, thorium dioxide known to have a tendency to plug the smaller lymphatic vessels was utilized in the study of this subject. Three live dogs were operated upon and their bladders were injected in various places with this radio-opaque material. In 2 dogs, all the large vessels were ligated. These animals were followed for 3 to 6 months by clinical observation and x-ray films before being subjected to autopsy. There was evidence of lymphatic blockage and retrograde edema in the tissues. Colin Lee and Gabrielle working on the lymphatics of animals in other portions of the body also reported evidence of retrograde lymphatic edema. Bralshaw and more recently Rouviere demonstrated experimentally that lymph nodes attacked by inflammation act as an obstruction. The lymph vessel dilates above the obstacle and backflow may become established in the unobstructed ducts, or else an edema persists.

The inconstant small lymph nodules, usually found along the sides of the obliterated hypogastric vessels, are not considered primary lymph glands. Occasionally these may be found on the anterior bladder wall and in the prevesical space. These tiny glands are regarded as intercalated (interposed) lymph nodules that is minute lymph elements interrupting a collector on its way to its primary echelon. These minute elements are not common and in most specimens not seen.

COURSE OF COLLECTORS

The lymphatic collectors in the anterior wall of the bladder will be described separately from those of the posterior wall. The trigone floor and inferolateral walls up to the level of the obliterated hypogastric vessels are included in the description of the posterior wall. For purposes of description these divisions, that is the anterior and posterior walls are further divided into upper middle and lower thirds.

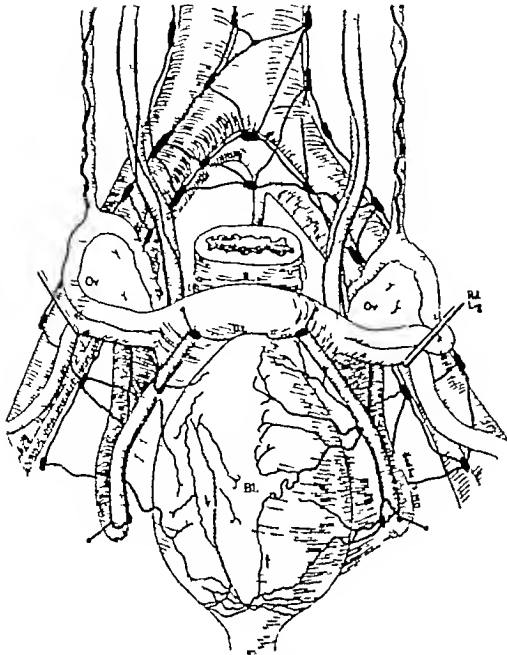


Fig 2 The position of the main lymph collectors of the anterior bladder wall as usually found are represented by those shown on the right side of the organ. An important variation is represented by the course taken by those on the left side.

Anterior wall When the material was injected in the upper third, fine lymphatic trunks were seen to arise and proceed downward and laterally toward the middle third where they usually turned more directly laterally and joined trunks coming from the middle third. In some instances, trunks passed directly laterally, joined similar trunks, and proceeded down beside or behind the obliterated hypogastric artery. Occasionally one began in the uppermost portion on either side of the midline. This ran along with or without a smaller satellite, proceeding directly downward to the lower third in the prevesical space. There it often turned abruptly laterally and formed a network of vessels, and then ran slightly upward to join the main collectors parallel with the obliterated hypogastric.

The main lymphatic ducts of the anterior wall appeared to arise from the middle third. They ran more laterally but great variations were to be seen. There was definite evidence to support Arguello-Cervantes' contention of

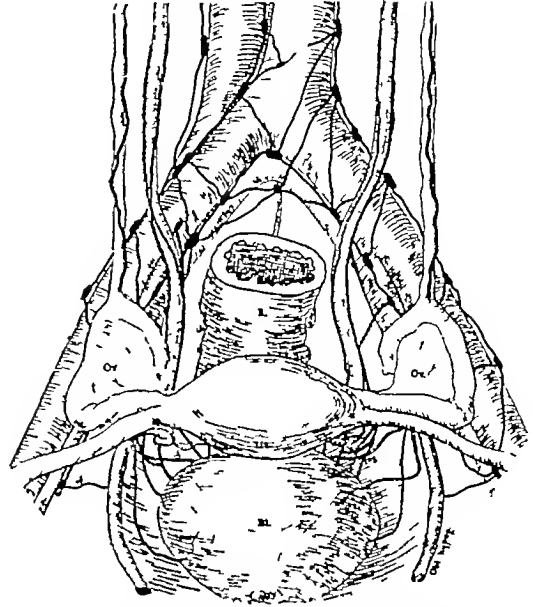


Fig 3 Composite semidiagrammatic sketch of the collectors of the posterior bladder wall. Note the fine network marked out of the injection mass being introduced into the lower segment of the uterus.

there being relatively little anastomosis of the lymph vessels on one side of the median line of the anterior wall with those on the opposite side. The lymphatic collectors usually fused and formed one large beaded vessel that received the ducts coming from the upper and lower thirds. This large collector occasionally passed through an intercalated node and proceeded down the lateral wall beside the obliterated hypogastric vessel, receiving trunks from the posterior wall and finally passed laterally, close to the origin of the ureter. In many instances, it was seen to ascend as single or multiple collectors on one or both sides of the ureter and at various levels to turn laterally to join primary nodes. Frequently they crossed the uterine artery and proceeded to the level of the brim of the pelvis before leaving the ureter (Fig 2).

In the prevesical space, there was a network of fine lymphatic vessels which had a definite connection with the entire neck of the bladder, posterior vagina, and cervix of the uterus. If injection was done in the outer muscular wall of the lower portion of the uterus and cervix,

the dye ascended in a retrograde manner through the network of the vessels under the trigone and on each side of the neck of the bladder and filled the network in the pre-vesical space. This network was connected with trunks which ran up laterally on each side and joined the main beaded collectors which drained the upper and middle thirds of the anterior and posterior walls of the bladder. Rarely a retrograde injection proceeded from the lower third directly up to the upper third of the bladder.

Posterior wall. When the injecting material was placed on one side or the other in the upper third the lymphatic network was seen to cross freely from one side to the other forming definite and intimate anastomosis and uniting the trunks from both sides of the midline. The trunks were relatively more numerous and were generally easier to inject and follow. This was partially explained by the fixation of a large part of the posterior wall. The paths of the trunks were not so constant as those of the anterior wall. The individual trunks frequently coursed laterally to the primary nodes without uniting with trunks coming from other portions of the bladder. In some specimens the trunks appeared to be more or less independent of the vessels of the middle third and joined the trunks coming from the upper and middle thirds of the anterior wall. The posterior trunks of the upper third were more intimately connected with those of the anterior bladder wall than were those of either the middle or lower thirds.

In the middle third of the posterior wall, the arrangement of the trunks was similar to that of the upper third except there were generally larger trunks and this portion had a more definite connection with the rich network over the trigone in the lower third. These trunks joined those of the anterior wall less often than those of the upper third.

In the lower third, over the trigone, the vessels were more numerous, and many individual trunks coursed separately to the primary nodes (Fig. 3).

CONCLUSIONS

1. The study of the lymphatics of the human urinary bladder convinces one that a

thorough knowledge of this system is of legitimate clinical importance.

2. This anatomical feature should be studied not only by the urologist who may treat diseases of the bladder but by any surgeon who operates upon the lower abdomen or pelvic organs, particularly of the female.

3. The lymphatic network begins in the submucosa where the tiny ducts run directly to the external surface and there join large collectors containing valves.

4. The valved collectors determine the course the lymph flows. Retrograde and collateral circulation may obviously be more difficult in these beaded (valved) vessels which often form the main trunks.

5. As a general rule the lymph system of the anterior wall of the bladder is drained by collectors on either side of the midline that fuse and form one large beaded vessel. These run down along the course of the obliterated hypogastrics on either side toward the neck of the bladder near the origin of the ureter. There they turn laterally after receiving trunks from the posterior wall and then join primary lymph nodes.

6. There is an occasional specimen in which the main trunk, instead of coursing along the side runs more nearly over the dome but usually to the side of the midline.

7. There is relatively little anastomosis of the lymph vessels from one side of the median line of the anterior wall with those on the opposite side.

8. There is a large network of small (unbeaded) lymph ducts completely surrounding the neck of the bladder which are intimately connected with those of the posterior wall of this organ as well as the cervix of the uterus.

9. The collectors of the posterior bladder wall, unlike those of the anterior wall usually leave the bladder separately to course to the regional nodes.

10. Over the floor or the posterior wall of the bladder there is abundant anastomosis of the fine lymphatic network of one side of the median line with those of the opposite side.

11. The posterior abdominal lymph nodes receive the lymphatics from the bladder and other pelvic organs.

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THE Rh FACTOR IN INTRAGROUP BLOOD TRANSFUSION REACTIONS

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THIS report concerns an Rh negative obstetrical patient who carried a dead fetus for 2 months and who then at the middle of the 7th month of pregnancy aborted a macerated stillbirth. Following the abortion because of uncontrollable uterine hemorrhage the patient went into shock. One hundred cubic centimeters of group O Rh positive blood was administered. A severe hemolytic transfusion reaction occurred and was followed ten days later by generalized convulsions. The patient gradually recovered.

Twenty five similar cases have been analyzed and are presented briefly.

The Rh factor has been shown to have an important part in at least four hitherto unexplained processes. These are the occurrence of hemolytic transfusion accidents after repeated transfusions with blood of the homologous group (26) the occurrence of similar reactions after the first transfusion in obstetrical patients (28-31) the frequent occurrence of complications of pregnancy in women with erythroblastic fetuses (24-29) and the uniting of universal edema of the fetus, icterus gravis neonatorum and anemia of the newborn under the one disease entity erythroblastosis fetalis (17-24, 28). The fundamental mechanism in all of these processes is the immunization of an Rh negative individual to Rh agglutinogens. The introduction of the agglutinogens may take place either by transfusion of Rh positive blood into an Rh negative individual or by the presence of an Rh positive fetus in an Rh negative mother. When the anti Rh agglutinins have reached a high titer as the result of immunization they may react with the introduced agglutinogens. If the introduction is by transfusion a

hemolytic reaction may occur. In the case of a pregnant woman she may deliver an erythroblastic infant or abort an erythroblastic fetus. Further details concerning the Rh factor may be found in recent reviews (9, 23, 40-46).

CASE REPORT

The patient was 36 year old Irish housewife, deservants, quintipara (4 living children, 4 spontaneous abortions). The last 3 pregnancies yielded term babies. The next to last baby is living and well, the last died 5 hours postpartum (cause unknown). The patient was registered in the antepartum clinic of the Sloane Hospital for Women on October 28, 1942. Physical examination showed no significant defects. Her last menstrual period was August 7, 1942, the estimated date of labor was March 14, 1943. The blood pressure was 115/70, the urine, normal. Her blood was group O and Rh negative. A tendency to excessive weight gain was noted in December and was corrected with 200 calorie diet. In January fetal movements ceased, and diagnosis of fetal death was made. This was substantiated by x-ray. Thereafter, the uterine size receded slightly and no further weight gain occurred. Throughout the remainder of the pregnancy the blood pressure averaged about 120/80. Faint trace of albumin appeared in the urine at the last clinic visit, March 20. On March 30, the patient was admitted in active labor and delivered precipitously while being transferred from the wheelchair to the bed. The fetus was a macerated stillbirth of 5 months size. The placenta was intact and fibrotic; the membranes were questionably intact. Continuous uterine bleeding occurred which could not be controlled by uterine massage, pituitrin, and ergonovine. Examination showed the cervix to be intact and no material could be felt inside the uterus. The uterine cavity was packed tightly with iodoform gauze.

The blood pressure by this time had fallen to 75/40, and the patient was in mild shock. A plasma transfusion was started, immediately and was followed by transfusion of group O blood compatible by the usual method of cross matching. This blood was Rh positive. One hundred cubic centimeters had been administered before examination of the patient's old chart revealed her to be Rh negative. The blood was stopped immediately and the plasma was continued. The patient's condition gradually improved with the blood pressure rising to 92/60.

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TABLE I.—CHANGES IN BLOOD CHEMISTRY

Normal values		Hematocrit (per cent)	Total proteins (grams per cent)	Electrolytes (millequivalents per liter)				Carbon dioxide combining power ¹	Potassium ²	Urea (mg per cent)
				Na ⁺	Cl ⁻	Ca ⁺⁺	Mg ⁺⁺			
Days	Time per run	41.25	7	142	96	97	66	40-45		
	11:00 a.m.	41.25	5.7	96						
	1:00 p.m.		5.4							69
	3:00 a.m.		5.7					27		66
	5:00 a.m.	41.1	5.66	84	8			23		66
	7:00 a.m.	35	6.6	125.6				4		97
6	10:00 a.m.	37	21							
	10:00 a.m.	36	54					73		100
8	10:00 a.m.	2	2					64		54
	10:00 a.m.	2.5	5.66	147				54		5
20	10:00 a.m.	27.5	7.32	147.8	94			64.5		56
	6:30	26	64	148.5	94			8	59	50
	4:15 p.m.									57
	10:00 a.m.	42	64	71	105			4		
	10:00 a.m.	40	70	54				54		70
22	8:00 a.m.	26	8.97	26	62	54	66			
	10:00 a.m.	26	25	145	97	96	91	16		
24	6:00 a.m.	26	27	143	96	97				100
	8:00 a.m.							77		97.8
26	10:00 a.m.	24	28							
27	10:00 a.m.	26	8.45							
28	10:00 a.m.	23	80					75		100
29	8:00 a.m.							64		8
34	10:00 a.m.	12	7					54		64

All determinations were done on venous blood.

¹Plasma.²Serum.

All hematocrits were centrifuged for one hour except the original determination.

This occurred in spite of 1,100 cubic centimeters of plasma and 900 cubic centimeters of blood. From this point, the proteins increased and reached 8.2 grams per cent on the 18th day. In all the patient received 3,700 cubic centimeters of plasma and 1,900 cubic centimeters of Rh negative blood roughly equivalent to 19 donors.

Plasma sodium. On the 3d day following the transfusion reaction, the plasma sodium was normal, 142.8 milliequivalents per liter. By the next morning it had decreased by 4.2 milliequivalents per liter. The values on the

day of the convulsions rose from 147.6 to 152.2 milliequivalents per liter following the hypertonic salt and adrenal cortical extract. By the next morning, this had increased still further to 154.4 milliequivalents per liter following which a decline occurred.

Plasma potassium. The venous blood taken after the 4th convulsion revealed the plasma potassium to be 4.4 milliequivalents per liter. After the 7th convulsion, this had increased to 5.19 milliequivalents per liter. After the hypertonic salt and adrenal cortical extract a level of 4.83 milliequivalents per liter was obtained. Three subsequent determinations on the 2d, 3d, and 4th days following the convulsions showed the concentration to be lower than the peak value but higher than the initial determination.

Plasma chloride. The chloride rose from 98.3 milliequivalents per liter taken after the 4th convulsion to 103.1 milliequivalents per liter following the administration of hypertonic salt. On the 3d day after the convulsions (13th posttransfusion day) the plasma chloride concentration was 91.9 milliequivalents per liter. Twenty-four hour urine specimens were then analyzed for sodium chloride. The first such specimen contained 13.5 grams sodium chloride in 4 liters of urine. She was then started on enteric coated sodium chloride pills, 1 gram every 4 hours.

Carbon dioxide combining power. This showed the greatest fluctuation of any electrolyte. The first determination done 2 days after the transfusion reaction and after alkalization revealed a value of 31.9 milliequivalents per liter. By the next day this had risen to 31.7 milliequivalents per liter. From this point on there was an increasing acidosis as shown by a fall to 13.4 milliequivalents per liter after the 4th convulsion. This condition was apparently corrected as judged by a return to normal during the succeeding days.

Nonprotein nitrogen. The nitrogen retention was manifest by a value of 69.2 milligrams per cent on the day following the transfusion reaction. This progressively increased, reaching 130 milligrams per cent after the 7th convulsion. From then on, the values fell slowly to 66.2 milligrams per cent on the 23d day following the giving of Rh positive blood.

TABLE II—INTRAGROUP AND Rb TRANSFUSION REACTIONS

[illegible]

agglutination or hemolysis of donor's cells in 8 and compatibility in 4. In 7 cases, the donor was proven Rh positive and the recipient Rh negative.

The reaction occurred during the transfusion in 8 instances or within 1½ hours after the transfusion. Chill and fever were recorded in 18 instances, vomiting in 10, and lumbar pain in 7. Among the late manifestations, oliguria was constant in all 25 cases. Hemoglobinuria was noticed in 12. In 10 cases, jaundice was reported. Eight patients developed convulsions. Edema and hypertension were noted 6 times. Dyspnea and cyanosis were frequent early manifestations. Bloody and dark urine was usually passed within a short time, there was rapid progression to oliguria and anuria in 3 fatal cases. In 4 cases, shown in Table II, (14, 25, 32, 45) the triad—diuresis, hypertension, muscular twitching or frank convulsions—occurred in sequence, but in the others, the appearance of diuresis was a turn toward recovery. There were 5 deaths in these 25 cases. The earliest occurred on the first day and the latest on the eighteenth.

It is also of interest to note that the pathology of the kidneys in fatal transfusion reactions is very similar to that found in crush injury cases with anuria (13), in both, there are similar pigment casts in the distal convoluted and collecting tubules and catarrhal changes throughout the nephron. In the crush injury cases of Bywaters (12), the clinical symptoms and chemical changes are strikingly similar to those in the case presented. These patients also went into shock, and following the treatment of shock by transfusions of whole blood or plasma, developed oliguria, edema, vomiting, hypertension, elevated non-protein nitrogen, increase in creatinine, and hyperpotassemia.

Van Slyke, Phillips, Hamilton, Archibald, Dole and Emerson (personal communication) have produced in dogs a similar syndrome and changes in renal histology by producing hemorrhagic shock, and reinjecting part of the withdrawn blood after laking its cells.

ANALYSIS OF STUDY

The majority of intragroup transfusion accidents occurring in pregnant or postpartum

No. _____	
Date _____	City No. _____
Name _____	Unit No. _____
Age _____	Color _____
Diagnosis _____	Private _____
Indication for transfusion _____	Semiprivate _____
Emergency — Yes _____ No _____	Floor _____
Last R.B.C., Hgb. Hematocrit _____	Ward _____
Group _____	Amount required _____ ml.
When wanted? Date _____	Time _____
Has patient's blood been sent to bank? Yes _____ No _____	
Has patient been transfused before? Yes _____ No _____	
Any transfusion reaction? Yes _____ No _____	
Previous pertinent obstetrical history	
abortions _____ stillbirths _____ neonatal deaths _____	
erythroblastosis fetalis _____ icterus gravis _____	
Has Rh been done? Yes _____ No _____	Rh + _____ Rh - _____
Has patient sent in donors? Yes _____ No _____	
Signed _____ (Attends g. or Resident's signature (no donors))	
Telephone requests can not be taken. Requests incompletely filled out can not be honored.	

Fig 2 Requisition form for blood transfusions used at Presbyterian Hospital. Includes questions relative to Rh factor, previous transfusion reactions, and pertinent obstetrical history.

patients are due to Rh incompatibility. There is little doubt of its importance in the case presented, for the father, all 4 of the living children, and presumably the aborted macerated stillbirth are all Rh positive. The mother's blood taken before the transfusion was Rh negative. Actual determinations of the anti-Rh agglutinins done by Dr Philip Levine (27) 2 weeks after the reaction demonstrated that it was anti-Rh₁ in specificity, that it had a very strong anti-Rh₁ titer of about 1:160-1:320, and that the anti-Rh was moderately active with a titer of about 1:40. This high titer may be the result of an especially activated process of isomunization which was due to the "dead fetus serving as an antigenic stimulus" (31) plus the transfusion. Thus because of the high titer of anti-Rh agglutinins, the introduction of a relatively small amount of agglutinin (100 c.c. of Rh positive blood) precipitated a severe hemolytic reaction. Since the occurrence of this near-catastrophe, it has become the established policy of the

Sloane Hospital for Women that no obstetrical patient shall be transfused with blood of unknown Rh unless the patient's Rh is known. In the event that she is Rh negative Rh negative blood is used for transfusion. When emergency transfusion is required and the patient's Rh has not been determined only Rh negative blood is used. When Rh negative blood is not available in either of these latter instances plasma transfusions are employed.

What should be done when such a hemolytic reaction occurs?

1 Stop the transfusion immediately and if the patient's condition requires it a plasma or serum transfusion should be substituted.

2 Prove that a hemolytic reaction has occurred by drawing and centrifuging the blood and examining the plasma for hemolysis. Test the patient's and donor's blood for Rh factor.

3 Secure compatible Rh negative blood to support the circulation as indicated.

4 Catheterize the patient 1 hour after the first appearance of the reaction, and examine the urine for hemoglobin, red blood cells, and pH.

5 Start alkalization immediately. This is accomplished by the administration of 4.0 grams of sodium bicarbonate by mouth every 4 hours and a 4 per cent solution of sodium bicarbonate by rectal tap every 4 hours. A $\frac{1}{4}$ molar sodium lactate solution may be used intravenously. Alkalization should be continued to maintain the urinary pH above 7.0.

6 Analyze the blood for hematocrit and non-protein nitrogen and the plasma for chlorides, carbon dioxide combining power and proteins daily.

7 Restore the cell volume and plasma proteins by giving Rh negative blood and plasma transfusions.

8 With the occurrence of oliguria, restrict the fluid intake to between 2,000 and 3,000 cubic centimeters daily to prevent overhydration.

9 If convulsions occur in association with increasing hemoconcentration and acidosis, extra sodium may be administered in the form of hypertonic saline. Eachatin may help by

causing sodium retention and potassium diuresis.

It is emphasized that the treatment of conditions such as this should not be empirical but rather directed toward correcting the acidosis, maintaining fluid and electrolyte balance and restoring cell volume and plasma proteins.

At the time of the hemolytic reaction, there is a lysis of not only the administered donor's blood but also the patient's own red blood cells. This is attributed primarily to an agglutinin and agglutininogen reaction. With this process, there is liberation of the various intra corpuscular constituents following which hemoglobinuria and oliguria become evident. The mechanisms involved have not been adequately explained although there are adherents to both the theories of tubular blockage by hematin casts and of renal arteriolar vasoconstriction. Whatever may be the basis, the oliguria in the case presented was severe and protracted and was not prevented by either prompt alkalization (16) or immediate compatible blood transfusion (19) and did not give way to diuresis until after the hemoglobinuria cleared. A few hours following the onset of diuresis, the patient entered a critical phase marked by repeated generalized convulsions and coma.

The cause of the convulsions is difficult to explain. They may be associated with changes in the electrolytes secondary to the oliguria. Prior to the onset of convulsions, there had been a rapid increase in hemoconcentration. When they occurred the patient was in acidosis, the nonprotein nitrogen was near its peak, and the chlorides were below normal. As the convulsions progressed there was a greater increase in the potassium than in the sodium concentration.

The convulsive action of potassium is known (6, 7, 20, 22). In one of our dogs dying in convulsions following the injection of potassium salts the cerebrospinal fluid concentration of this cation was 13.2 milliequivalents per liter and in another 13 milliequivalents per liter (36, 37).

This patient was given hypertonic saline intravenously as such solutions cause reduction in brain volume and dilution of the blood. Fur-

*This would not be of very immediate help in the acidosis. It would serve best to use injections of sodium chloride plus sodium bicarbonate, or in severe acidosis of sodium bicarbonate alone as an chloride. In the case reported, these latter of sodium sodium bicarbonate solution would have been required to raise the plasma carbon dioxide from the level of 20 equivalents to normal.—Lee 57b.

ther, sodium salts are known to protect against lethal doses of potassium in animals and to lower the level of potassium in the blood (2, 5, 10)

Adrenal cortical extract has been shown to have a similar action (33, 42, 43, 44, 47) It was used here in conjunction with salt

One is not justified in attributing the subsequent favorable course to this therapy alone. However, the convulsions decreased in severity and ceased. Blood dilution was secured, blood potassium fell, the concentration of sodium rose, and the acidosis was corrected. The data are incomplete. In the future more studies should be carried out in similar cases before any definite conclusions can be drawn.

To obviate such transfusion reactions, a requisition form for blood transfusions has been introduced in the Presbyterian Hospital. This form embodies questions relative to the Rh factor, previous transfusion reactions, and pertinent obstetrical history (Fig. 2)

SUMMARY

A case is presented in which an Rh negative obstetrical patient sustained a severe transfusion reaction following 100 cubic centimeters of Rh positive blood. The reaction was characterized by chill and fever, hemoglobinuria, jaundice, oliguria, and convulsions. The blood chemical findings are tabulated. Twenty-five similar cases of intragroup transfusion reactions have been selected from the literature. A rational, although tentative, method of therapy is outlined. It is emphasized that under no circumstances should obstetrical patients be transfused with Rh positive blood unless the patients have been tested for the Rh factor.

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EXPERIMENTAL HEAD INJURY WITH SPECIAL REFERENCE TO CERTAIN CHEMICAL FACTORS IN ACUTE TRAUMA

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THE oxidative metabolism of the brain in head injury is a subject which requires further investigation. Clinical observations suggesting the occurrence of cerebral anoxia and possible factors in its causation following craniocerebral injury have been discussed by Schreiber. Schnedorf and associates noted a decrease in the oxygen saturation of the arterial blood in 8 of 9 dogs subjected to experimental head injury and found low arterial blood oxygen in 10 of 12 patients with concussion of the brain. Lindquist and LeRoy studied the cerebral blood flow in the dog by means of a thermistoruhr placed on the right common carotid artery, the right external and the left internal carotid arteries being ligated and the vertebral blood flow intact. A decrease in cerebral blood flow was observed following head injury and determinations of the oxygen contents of arterial and of external jugular blood showed a slightly decreased arteriovenous difference. These authors concluded that the cerebral oxygen consumption was decreased as a result of the trauma, and suggested that the ability of the nerve cells to use oxygen may be directly impaired by injury.

The present report on experimental craniocerebral trauma in dogs includes data on the oxygen saturation of the arterial blood and on the cerebral arteriovenous differences in oxygen, carbon dioxide and glucose the cerebral blood being taken from the sagittal sinus. Chemical studies of cerebral tissue have been made by the technique of freezing the brain *in situ* prior to removal of specimens for analysis. This procedure stops all metabolic processes in the tissue and prevents post mortem chemical changes.

Since it has previously been shown that acute anoxia induces rapid lactic acid formation and phosphocreatine decomposition in cerebral tissue (21) it is to be expected that any serious disturbance in the cerebral oxidative metabolism following head injury would manifest itself in similar changes.

It is generally recognized that glucose supplied by the blood is the primary substrate of the cerebral oxidative metabolism. One of the chief mechanisms of glucose catabolism in the brain is the well known phosphorylation cycle of Meyerhof and others (2, 3, 7, 14) in which glucose is converted to hexose phosphate and subsequently through a series of reactions is transformed to pyruvic acid. In the presence of adequate oxygen pyruvic acid is further oxidized to carbon dioxide and water through a series of steps not yet elucidated. In absence of oxygen, pyruvic acid is converted to lactic acid.

Whether other pathways for oxidation or for lactic acid formation exist in cerebral tissue is disputed (2, 3, 7, 14) but the phosphorylating mechanism is undoubtedly present and functioning. The present study deals with some of the constituents involved in this cycle: lactic acid, the level of which (in cerebral tissue) appears to depend primarily upon metabolic conditions such as oxygen supply and functional activity or oxidative rate; adenosine triphosphate which acts as a phosphate carrier in the phosphorylation of glucose and various intermediary metabolites; phosphocreatine which functions as an organic phosphate reservoir in equilibrium with adenosine triphosphate; inorganic phosphate and other acid-soluble phosphorus compounds the significance of which is still obscure. In some experiments the iron contents of the tissue specimens were determined to

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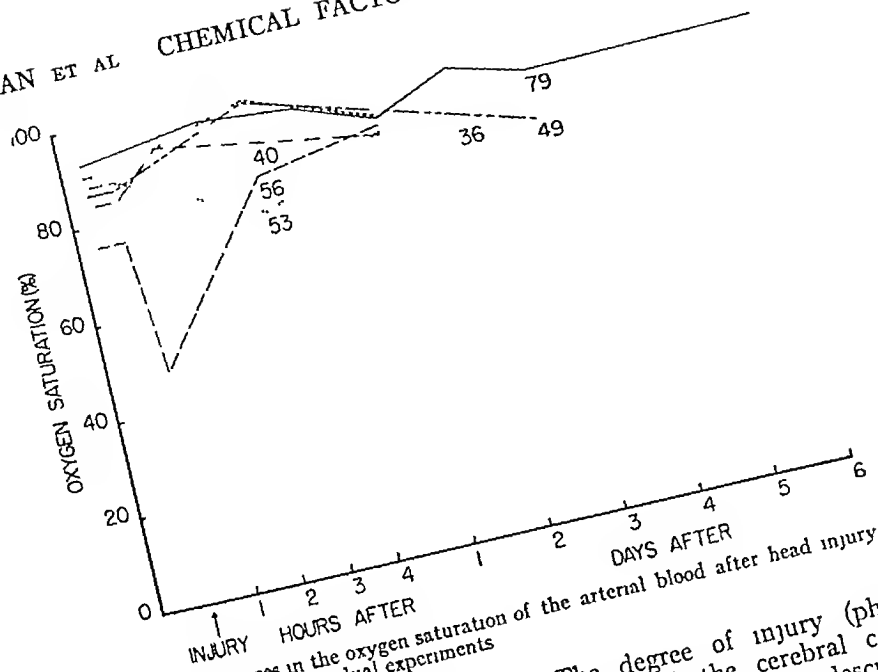


Fig 1. Changes in the oxygen saturation of the arterial blood after head injury. Numerals identify individual experiments

estimate the amounts of blood present, and determinations of the acid-insoluble phosphorus (phospholipid and nucleoprotein) were used as possible indication of presence or absence of localized edema

PROCEDURES

Mongrel dogs weighing between 5 and 15 kilograms were used. Morphine analgesia was employed in doses of 20 milligrams per kilogram, and infiltration with $\frac{1}{4}$ of 1 per cent procaine was used for exposure of vessels and other operative procedures. Blood specimens were drawn over mercury from the femoral artery and the femoral and external jugular veins, without stasis, before and after injury. Specimens were obtained also from the sagittal sinus after injury. In 1 to 6 day preparations the skin incisions were opened each day and closed again after the wound was sprayed with sulfanilamide powder. These wounds remained remarkably free from infection.

The head injuries were administered with a 1 pound hammer or with a device previously described (5) in which the striking object is propelled by springs. In acute experiments the scalp and masseter muscles were reflected before injury. In 1 to 6 day preparations the head injury was made over the intact scalp

The degree of injury (physiological response) and the cerebral contusions were classified as previously described (5). The state of consciousness was evaluated, as before, by observing the animal's response to tail pressure. In one instance (dog 56) the injury was classified as "profound" despite the fact that the animal survived until sacrificed 24 hours later, this animal was kept alive only by giving artificial respiration for 7 minutes after the blow. In 3 animals sacrificed 15 to 50 minutes after injury the classification "profound" was used since the injury was so severe that survival appeared to be extremely improbable. In one of these, artificial respiration was necessary for 5 minutes. In acute experiments the blood pressure was recorded from the femoral artery and respiration from a balloon about the thorax or from an intratracheal tube. The skull was exposed through a median incision and the masseter muscles were reflected laterally. After the injury had been administered, a trephine opening was made over the sagittal sinus and blood specimens were obtained. The bone of the calvarium was cut away until the superior lateral aspects of both hemispheres were exposed. The dura was opened and reflected. The brain was frozen *in situ*



Fig. 2. Blood pressure and respiration in a profoundly injured animal. The third blow caused marked pressure response, with loss of respirations for 30 seconds followed by occasional respiratory movements for 30 seconds. With return of respiration there was return of blood pres-

sure to the normal level. Lid reflexes returned minutes after blow but animal remained unconscious. The lens was frozen 30 minutes after injury. A conscious subject to the fracture showed typical chemical changes, while in an anesthetized contralateral area no changes were found.

with liquid air (9) and specimens of tissue were removed for chemical analysis. Cortical areas from which specimens were obtained included the postcruciate, coronal, ectolateral, infrasyllvian and ectosylvian gyri.

In 1 to 6 day experiments the procedure was similar except that blood pressure and respiration usually were not recorded.

CHEMICAL METHODS

Oxygen content and capacity and carbon dioxide content of blood were determined by the Van Slyke-Neill manometric methods (15).

Blood glucose was determined on zinc hydroxide centrifugates by the method of Hagedorn and Jensen as modified by Kramer and Steiner.

Lactic acid was determined by the method of Barker and Summerson.

The methods for fractionation and determination of the acid-soluble phosphorus compounds have been described (20). Precipitation by means of calcium hydroxide and 10 per cent ethanol separates inorganic phosphorus, most of the nucleotide phosphorus, and an acid-stable fraction which seems to consist largely of hexose-6-monophosphate. Unprecipitated are phosphocreatine, an acid-

stable fraction precipitated by 80 per cent ethanol, and an ethanol-soluble fraction.

The nucleotide phosphorus present in normal brain consists mainly of adenosine triphosphate but may include a small amount of guanosine triphosphate (10). These compounds appear in the Ca-insoluble fraction. Two of the three phosphate groups in each case are freed by acid hydrolysis, while the third remains combined with the ribose component of the molecule. The ribose component is quantitatively determined by an adaptation of Blal's reaction for pentoses, and the amount of attached phosphorus calculated. In normal cerebral tissue this equals half the acid hydrolyzable phosphorus precipitated. Adenosine diphosphate if present (as in postmortem tissue) appears in the precipitate but adenylic acid (adenosine monophosphate) is found in the Ca-soluble fraction. Only a trace of such Ca-soluble pentose-containing material is found in normal cerebral tissue; an increase (such as is found postmortem) is indicative of decomposition of adenosine triphosphate.

Iron was determined in the washed tri-chloroacetic acid precipitate by the method of Kennedy (8) and the amount of blood in

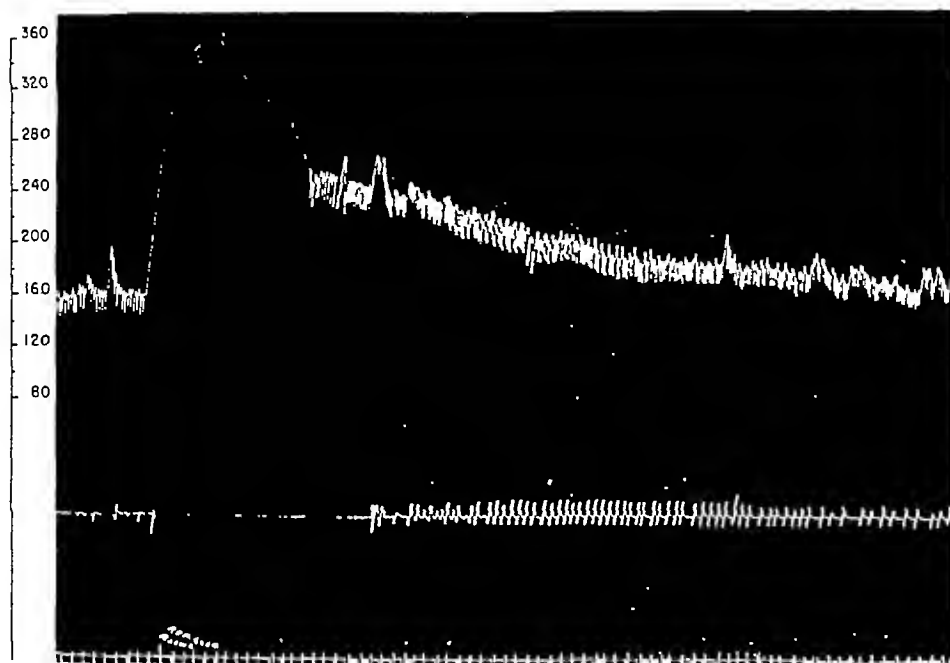


Fig 3 Blood pressure and respiration in a moderately injured animal. The second blow caused a marked pressor response with loss of respirations for 102 seconds. No loss of hd reflexes occurred. The animal did not respond to pain from tail pressure but responded to pain from manipulation of the dura. The brain was frozen 37 minutes after injury. A contusion subjacent to the fracture showed typical chemical changes. An unbruised adjacent area showed slight changes, while a contralateral area gave normal values for the constituents determined.

the specimen calculated from the equivalent oxygen capacity (15) and the oxygen capacity of the animal's blood. Allowance was made for a trace of nonhemoglobin iron present; this, determined on the perfused brains of 2 animals, was 0.8 milligram per 100 grams.

Acid-insoluble phosphorus was determined on appropriate aliquots of the digests used for iron determinations.

RESULTS

Oxygenation of arterial blood. The most common finding was increased oxygenation after head injury. This was observed in 22 of a total of 30 animals in which samples were obtained 14 to 180 minutes after injury. One animal showed no change, and 6 showed mildly decreased oxygenation. One profoundly injured animal with respiratory paralysis (dog 56) was given artificial respiration manually for 7 minutes, after which the respiratory function recovered. Arterial blood

drawn 15 minutes after injury showed an oxygen saturation of only 49 per cent. 150 minutes later the oxygenation had recovered to a value of 81.3 per cent, which was slightly higher than the initial level. The results of several experiments are plotted in Figure 1. The variations in the arterial blood gases are to be ascribed to respiratory changes, for the most part. Figures 2 and 3 show typical changes in respiration and blood pressure.

It may be noted that morphine induces only minor changes in the arterial blood gases. Average values showed a slight decrease in oxygenation and a corresponding increase in carbon dioxide content, indicating a very mild depression of respiratory activity, as compared with control animals given only local anesthesia.

Cerebral arteriovenous differences. In the injured animals no significant changes occurred in the cerebral arteriovenous differences in oxygen, carbon dioxide, and glucose. Deter-

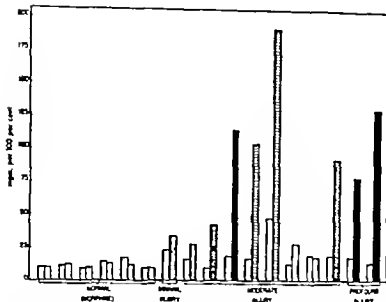


Fig. 4. Effects of cranial trauma on cerebral lactic acid, 30 to 85 minutes after injury. In areas of contusion there are great increases in lactic acid, roughly correlated to the grade of contusion but not with the degree of physiological injury. Areas both above and below evidence of contusion there is sometimes higher than normal lactic acid level. In other instances the level is normal, even in profoundly injured animals. Each pair of columns represents one brain. Right column shows result in specimen from area adjacent to fracture; left column from area contralateral to fracture. White columns, no contusion; dotted columns, contusion grade 1; horizontal lines, contusion grade 2; black, contusion grade 3.

minations made 18 to 75 minutes after injury in 12 animals gave an average of 8.6 volumes per cent oxygen removed from the blood as it passed through the brain. The corresponding average value in 21 morphinized control animals was 7.6 volumes per cent. The average values for carbon dioxide added to the blood were 7.6 volumes per cent in the injured animals and 7.9 volumes per cent in the controls. The average values for glucose removed from the blood were 14 milligrams per cent after injury (7 animals) and 12 milligrams per cent in the controls.

No generalized disturbance in the cerebral metabolism is revealed by these data. If any decrease in the oxidative rate occurred it was paralleled by a decrease in the cerebral blood flow. No measurements of the latter were attempted in these experiments. It should be noted that any increase in intracranial pressure was relieved by the trephine opening before the blood specimens were drawn.

In 4 control animals the cerebral arterio-venous differences were determined both with and without morphine analgesia. The average differences found without morphine were 6.3 volumes per cent of oxygen and 6.3 volumes per cent of carbon dioxide. Under morphine the average differences for the same dogs were 4.8 volumes per cent of oxygen and 6.0 volumes per cent of carbon dioxide. Decreases occurred in 3 instances and increases in 1.

Blood from the external jugular vein showed a higher oxygen saturation than that from the sagittal sinus in normal and injured animals. It is evident from the data that in the dog the blood of the external jugular vein is a mixture of cerebral venous blood with variable amounts of blood from other parts of the head, and is not suitable for studies of cerebral metabolism.

Chemical changes in cerebral tissue. Acute changes have been studied in 15 injured animals, 5 to 85 minutes after injury. Areas of

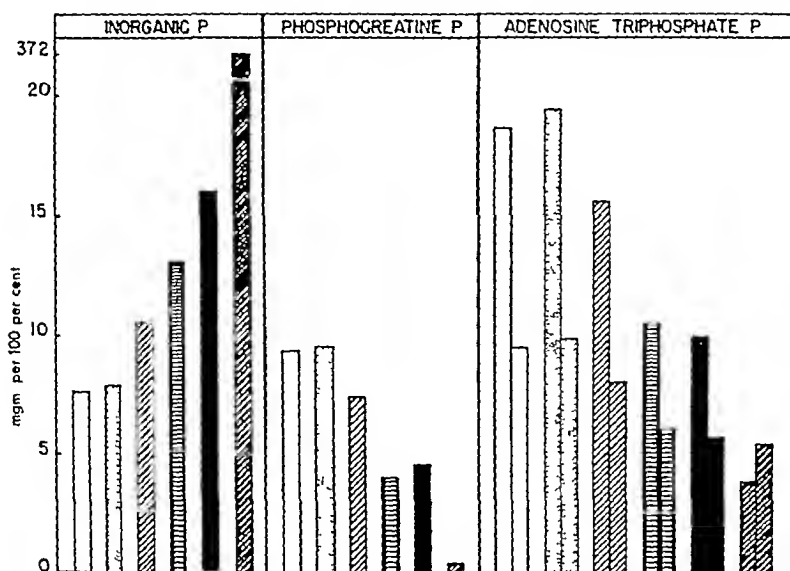


Fig 5 Effects of cranial trauma on cerebral inorganic phosphate, phosphocreatine, and adenosine triphosphate, 20 to 85 minutes after injury. Unshaded columns represent averages of values from 6 uninjured dogs. Shaded columns represent averages of values from 2 to 4 animals. No changes are found after injury in unbruised areas or in grade 1 contusions. With more severe bruising, inorganic phosphate is increased at the expense of the organic fractions. Still greater changes occur postmortem in animals not subjected to cranial trauma. In the case of adenosine triphosphate, 2 of the 3 phosphate groups are determined after acid hydrolysis. The third, which remains bound to the ribose component, is calculated from a determination of the ribose. The normal 2 to 1 relationship changes but little in contusions. After post mortem decomposition for 30 minutes, the lower ratio indicates that the nucleotide remaining in this fraction is mostly the diphosphate. White columns, no contusion, dotted columns, contusion grade 1, diagonal lines, contusion grade 2, horizontal lines, contusion grade 3, black columns, contusion grade 4, black with white diagonal lines, postmortem. In the adenosine triphosphate group the right column shows acid hydrolyzable P, the left column ribose monophosphate P.

the cortex showing no macroscopic evidences of contusion often appeared to be entirely normal as regards the chemical constituents studied, even in profoundly injured animals. In other cases the lactic acid was slightly or moderately increased in areas showing no petechial hemorrhages. Changes in acid-soluble phosphates were absent from these areas or were so small as to be of doubtful significance. In one animal the specimen contralateral to the injury showed normal phosphates and only a slight increase in lactic acid, although on the injured side there was extensive laceration with extrusion of much cerebral tissue, and the animal remained unconscious to the end of the experiment.

Areas of the cortex which had sustained visible contusion showed marked chemical

changes which were roughly proportional to the degree of local damage but bore no relation to the physiological response of the animal. Lactic acid changes in representative experiments are shown in Figure 4, and changes in acid-soluble phosphates in Figure 5.

A question immediately arose concerning the effects of extravasated blood on the chemical findings in areas of contusion, especially as to the apparent decreases in acid-soluble phosphorus compounds. The possibility of a localized edema also required consideration.

In 6 experiments the amounts of blood in the tissue specimens were estimated from iron determinations. It was found that grade 4 contusions might contain as much as 30 per cent blood, while normal tissue contained about 5 per cent. Acid-insoluble phosphorus

was determined in these specimens and the values found were corrected by calculating the amounts present in 100 grams of tissue exclusive of blood. In 5 of the 6 experiments the corrected values showed an apparent decrease of acid-insoluble phosphorus in the contusions (6 to 14 per cent) as compared with contralateral areas the specimen not showing this decrease represented a milder degree of contusion than the others. The effect may have been due to "dilution" of the tissue by localized edema or to actual loss of phosphorus from other causes. Since the acid insoluble phosphorus represents relatively stable tissue material (phospholipid and nucleoprotein) its apparent decrease in contusions is thought to be due to localized edema.

In these 6 experiments the values found for the acid-soluble phosphorus compounds were corrected by calculating the amount of each constituent present in 100 grams of tissue exclusive of blood and exclusive of apparent edema fluid in the contusions. Allowance was made for the acid-soluble phosphorus compounds in the blood. However after the corrections were applied the results remained qualitatively the same as shown in Figure 5.

It is therefore concluded that in areas of contusion there occur formation of lactic acid and partial decomposition of phosphocreatine and of adenosine triphosphate with accumulation of inorganic phosphate. The nucleotide phosphorus which remains is chiefly adenosine triphosphate with little or no adenosine diphosphate. The ribose component of the decomposed adenosine triphosphate apparently disappears. A slight loss of total acid soluble phosphorus usually occurs. The corrected values for "residual organic phosphorus" fractions did not indicate the occurrence of significant changes.

Later course of changes. In 11 experiments, cerebral tissue was obtained for analysis 1 to 6 days after injury. The findings are similar to those immediately after injury. Precise evaluation is impossible in the absence of a method for producing strictly comparable injuries in different animals but there appears to have been a measure of recovery as regards lactic acid and phosphocreatine in

several of these experiments. In no case was the lactic acid above 100 milligrams per 100 grams in this group and in several instances low lactic acid levels were found in grade 1 contusions, in striking contrast to the findings immediately after injury. In one experiment there was an apparent loss in "residual organic phosphorus" fractions, but unfortunately no values for blood in the specimens were obtained in these experiments. These results are presented as preliminary experiments only further studies of chemical changes during recovery are planned.

ANALYSIS OF OBSERVATIONS

Lactic acid and phosphocreatine levels in cerebral tissue. In the course of this and other investigations a series of determinations of blood plasma lactic acid has been made simultaneously with determinations on cerebral tissue frozen *in situ* under various conditions. The data confirm previously published evidence (18) that the cerebral lactic acid is independent of the level in the blood, being in some instances much higher and in others much lower. Other workers have shown that the "hematoencephalic barrier" is relatively impermeable to anions (4). Since lactic acid is largely ionized at the pH of the blood it is probable that its rate of diffusion between blood and brain is relatively low. From observations of the effects of hypoxia and other conditions on the cerebral lactic acid level it is evident that the latter is regulated primarily by metabolic conditions within the cells. Experiments have shown that in dogs under morphine the cerebral lactic acid begins to increase when the oxygen in the respired air is reduced to between 11 and 13 per cent (oxygen-nitrogen mixtures) at which level the oxygen saturation of the arterial blood is 55 to 65 per cent. Varying the period of hypoxia between 15 and 60 minutes does not change the lactic acid level. Upon readmission of air after relatively mild degrees of hypoxia the cerebral lactic acid level returns to normal within 10 minutes for the more severe degrees of hypoxia within 45 minutes.

The phosphocreatine level in the brain is decreased by hypoxia, the decomposition beginning at oxygen levels of approximately

7 per cent in the respired air, corresponding to an arterial blood oxygen saturation of 23 to 35 per cent. Complete recovery of phosphocreatine occurs within 10 minutes after readmission of air in even the most severe degrees of hypoxia studied.

The lactic acid and phosphocreatine in the brain may also vary with the oxidative rate or with the functional activity of the neurones. Lactic acid values found in mice under ether or barbitalurates are lower than those in unanesthetized controls. Phosphocreatine is increased by barbiturate anesthesia. Lactic acid is increased by sensorimotor activity (exercise) and in convulsions induced by picrotoxin or metrazol (18, 19). In dogs, morphine analgesia gives more uniform lactic acid values with a slightly lower average than does barbiturate anesthesia (11).

Unbruised areas from injured brains. The cerebral lactic acid and phosphocreatine levels found after craniocerebral trauma do not indicate the occurrence of a generalized cerebral anoxia. Since mild degrees of hypoxia, well tolerated by the animal, are sufficient to cause increased lactic acid in the brain, the frequent finding of normal lactic acid levels in apparently undamaged areas of the cortex in animals suffering from profound injury may be taken as an indication that the oxygen supply and utilization is sufficient in these areas.

In other instances, in the presence of adequate arterial oxygen, the occurrence of higher than normal lactic acid levels in areas which show no visible evidence of contusion may represent a mild degree of local damage. This interpretation is suggested by an experiment in which such an area was found directly beneath the skull fracture, together with a lower (normal) lactic acid level in contralateral area. However, the occasional occurrence of a generalized disturbance in cerebral oxidations is not excluded by these experiments.

In some instances subdural hemorrhage occurred. The cerebral tissue subjacent to such mass lesions was often found to be normal with regard to lactic acid and phosphorus compounds. It cannot be denied that with the skull intact a subdural hematoma may cause localized anoxia by compression which would not be present when the bone is removed and

the brain is decompressed. The same is true of severe degrees of brain swelling.

Contusions. The chemical changes in areas of contusion are comparable to those in cerebral anoxia in that lactic acid is formed and phosphocreatine decomposed, with accumulation of inorganic phosphate. The two conditions differ markedly in respect to adenosine triphosphate which is decreased by contusion but not by the most severe oxygen deprivation studied, a level of 4.2 per cent in the respired air, which approaches the level of fatal anoxia. The disappearance of small amounts of acid-soluble phosphorus from areas of contusion is not paralleled in hypoxia.

Chemical changes occurring in cerebral tissue postmortem include decomposition of phosphocreatine and adenosine triphosphate. The decomposition products of the latter are found as adenosine diphosphate, adenylic acid, a nucleoside or free pentose, and inorganic phosphate (20). In areas of contusion the findings differ in that phosphocreatine and adenosine triphosphate do not completely decompose, furthermore, the organic products of the decomposed adenosine triphosphate have largely disappeared.

The chemical changes in areas of contusion may be the result of a combination of direct injury to the cells and anoxia resulting from local vascular damage.

Animal-human correlations. The reaction of the human patient to head injury differs in some respects from that of the dog. In the latter, either the injury causes death within a period of a few minutes to an hour, or the effect is comparatively mild, the animal recovering to a relatively normal state within an hour or two after the blow. Lengthy periods of unconsciousness lasting for many hours or days, such as are frequently seen in the human, have not been observed in the dog in the course of these experiments.

There is also a marked difference between the animal and the human in the pattern of delayed death. In the animal, delayed death is associated with failing circulation of a shock-like state and gradual respiratory failure. The clinical findings of increasing blood pressure with bradycardia followed by pulmonary edema commonly noted in the

human were not observed in the experimental animal. In the human, anoxic anoxia may be a factor in the presence of pulmonary edema.

There was a marked difference in the incidence of subdural and epidural clots. Although these lesions are common in the human they were rare in the dog. Anatomical differences between the human and the dog probably account for these variations. There are fewer pial-dural venous connections in the dog's brain a circumstance which reduces the likelihood of rupture and subdural collections.

Contusions of the brain are common in the human with head injury. They have been observed in 47 per cent of 151 postmortem examinations, and in the 72 individuals there were 191 distinct bruises (6). The effects of areas of contusion on the general brain economy should be remembered in management of such cases. Further experimental work should clarify the value of oxygen therapy and its effects on the anoxic state in areas of contusion.

SUMMARY

1. The cerebral metabolism has been investigated in dogs subjected to experimental cranio-cerebral trauma.

2. The oxygen saturation of the arterial blood was usually found to be increased after head injury. In a few instances saturation was observed. These changes were due mainly to variations in respiratory function.

3. The cerebral arteriovenous differences in oxygen, carbon dioxide and glucose have been measured. Cerebral blood being obtained from the sagittal sinus. Head injury did not cause significant changes in these values.

4. Specimens of cerebral tissue for chemical analysis were obtained by freezing the brain *in situ*. Studies were made of lactic acid and acid soluble phosphorus compounds. In some experiments amount of blood in each specimen was estimated from iron content. Acid insoluble phosphorus also determined.

5. Areas of the cortex showing no macroscopic evidences of damage were sometimes entirely normal as regards the chemical constituents studied even in profoundly injured animals. Since a mild degree of hypoxia causes increased lactic acid it is concluded

that no generalized disturbance in cerebral oxidations resulted from the head injury.

6. In other instances the lactic acid was slightly increased in cortical areas showing no macroscopic evidences of contusion and in the presence of adequate arterial oxygen. This finding may represent either a mild degree of local damage or a more widespread disturbance in cerebral oxidative mechanisms in these animals.

7. Areas of contusion showed greatly increased lactic acid and inorganic phosphate and decreased phosphocreatine and adenosine triphosphate. The organic decomposition products of adenosine triphosphate had largely disappeared, in contrast to the findings in postmortem tissue. A slight loss of acid-soluble phosphorus usually occurred. These findings may be due to a combination of direct injury to the cells and an *in vivo* result from vascular damage.

8. In brains studied 1 to 6 days after injury there appeared to be partial recovery as regards the lactic acid and phosphocreatine in areas of contusion.

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TRANSLOCATION OF THE PERONEUS LONGUS TENDON FOR PARALYTIC CALCANEUS DEFORMITY OF THE FOOT

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A DECADE ago von Baeyer (1, 2) wrote a rather broad article discussing the merits and procedures for translocation of tendons. The idea at that time was not new but was seldom used and he considered the procedure worthy of more common use and consideration. By translocation he meant the changing of the course of a tendon muscle preparation to perform a new function without severing the origin or insertion of the muscle. When such an operation was possible he believed that it had several advantages over the transplantation of tendons as is commonly done. It is not necessary to depend on the sutures to hold the tendon at its new point of insertion. Early function of the translocated muscle and tendon is possible, and fewer adhesions are likely to form. Von Baeyer also expressed the belief that the tension under which the translocated tendon and muscle were placed caused the muscle to hypertrophy and so better serve its function in taking over the duties in replacing a usually stronger muscle. He proved this latter point to his satisfaction in experimental animals and refuted previous beliefs that muscles under tension tend to atrophy. It is reasonable to assume that the stimulus to the reflex arc from one of these muscles is less disturbed when the origin, insertion, and physiological tension of the muscle are kept intact.

No subsequent reports of this procedure as applied to the peroneal muscles have been encountered in the English literature by us. In searching for an operation which would supply active plantar flexion to a foot with a paralysis of the gastrocnemius and soleus muscles which had assumed a calcaneal deformity, the surgeons at the Gillette State Hospital for Crippled Children at St. Paul, Minnesota, believed the procedure as suggested by von Baeyer was worthy of a trial. The results from transplant-

ing the cut peroneal tendons into the tendo achillis or the calcaneus had not been considered too successful. In 1937 a small series of these operations was begun and enough time has elapsed that an evaluation of this procedure should be made.

A total of 13 patients have undergone this operation, the last one included in this group having been done in January, 1942. The patients selected all had had poliomyelitis and had reached the residual stage. One patient was operated on only 1 year after the acute episode of poliomyelitis, the remainder had had the disease at least 5 years prior to operation. The longest interval between the disease and operation was 8 years while the average was 5 1/2 years. The average age of these patients was 9 1/2 years, the youngest being 5 years of age and the oldest 15 years. There were 7 male and 6 female patients in the group.

The previous medical treatment had been of the conventional conservative nature with active physical therapy following the acute stage. Two patients had had previous surgical procedures: one patient had had a Hoke type of tendon transplant of the foot combined with plantar fasciotomy, in another case an unsuccessful attempt had been made to perform anterior bone block of the ankle.

The presenting complaint of all 13 patients selected for this operation was a calcaneus deformity. Seven of these had an associated valgus deformity of the ankle and foot. In 4 cases some cavus deformity was present. Careful evaluation of the muscle strength in all muscles of the leg was made (Table I). In the majority of cases the operation was done only when the strength in the peroneal muscle was rated as fair or better. In 2 cases in which the preoperative rating for the peroneal muscles was "poor," operation was performed. In 1 of these cases the result was poor while in

TABLE I.—PREOPERATIVE MUSCLE POWER AND RESULT OF OPERATION IN 13 CASES OF TRANSLOCATION OF THE PERONEUS LONGUS TENDON

Case	Preoperative muscle power						Rank of operation
	Gastrocnemius	Flexor digitorum longus	Flexor hallucis longus	Tibialis posterior	Peroneus	Tibialis anterior	
1	Poor	Normal	Normal	Poor	Normal	Poor	Good
2	Poor	Fair	Fair	Fair	Good	Good	Good
3	Poor	Fair	Poor	Good	Good	Good	Poor
4	Trace	Fair	Good	Fair	Normal	Good	Fair
5	Poor	Fair	Fair	Poor	Fair	Good	Poor
6	Trace	Good	Trace	Good	Poor	Trace	Very good
7	Trace	Good	Good	Poor	Fair	Fair	Good
8	Trace	Good	Good	Fair	Good	Good	Fair
9	Fair	Good	Good	Good	Good	Good	Excellent
10	Poor	Poor	Poor	Fair	Good	Good	Very good
11	Fair	Normal	Fair	Good	Normal	Good	Very good
12	Trace	Poor	Poor	Trace	Fair	Trace	Poor
13	Trace	Good	Good	Good	Good	Good	Good

the other it must be rated as very good. In all but 2 cases the power in the gastrocnemius and soleus muscles was rated from poor to trace. In two cases there was fair power in the gastrocnemius group and when this was supplemented by a sound peroneal which was translocated the plantar function of the foot was respectively excellent and very good.

Since the translocated peroneal tendon can at best only partially fulfill the function of the gastrocnemius and soleus muscles, any added strength from these muscles enhances the success of this operation. Likewise the strength of the flexor hallucis longus and the flexor digitorum longus as well as the posterior tibial muscle aids in plantar flexion; the latter muscle together with the peroneus brevis gives lateral stability to the foot. The power in the tibialis anterior muscle appeared not to have any effect upon the results from the procedure under discussion.

In only one of the cases in which operation was performed has it been found necessary to stabilize the foot by either a triple or a subastragalar arthrodesis. Two of the more severely involved patients are still wearing braces and may need some bony stabilization

at a future date. One of these patients had a good result; the other obtained an unsatisfactory result.

OPERATIVE PROCEDURES

After the customary sterile preparation and draping a tourniquet is applied to the thigh. A curved incision is made over the course of the peroneal tendons extending from about 2 inches (5 cm.) above the lateral malleolus around this structure and to the point where the peroneus longus passes beneath the tarsal bones to its insertion on the lateral aspect of the base of the first metatarsal and the inferolateral aspect of the first cuneiform bones. The peroneal retinaculum is split and the peroneus longus tendon is mobilized. A second longitudinal incision is made around the apex of the heel in the midline and extending down to the periosteum. This incision is then connected with the first by deep subcutaneous dissection (Fig. 1). With a wide osteotome a V shaped groove is cut into the calcaneus over its apex for about 1 inch (2.5 cm.). This groove must be deep enough to receive the peroneal tendon (Fig. 2). With an ordinary button hook inserted in the second incision the peroneus longus tendon is pulled around into this new sulcus. Extreme plantar flexion of the ankle and foot aids in this maneuver. The tendon is inspected through the first incision and it is made certain that the plantar dissection has extended far enough medially to allow the tendon as direct a pull as possible in its new bed across the apex of the heel (Fig. 3).

The superior and inferior peroneal retinacula may then be repaired with a continuous suture or a few interrupted sutures of chromic catgut. Subcutaneous tissue is closed with interrupted plain catgut and the skin with plain interrupted suture sutures. A padded cast is applied from the toes to the knee with the ankle in about 45 degrees of plantar flexion.

The foregoing procedure was used in the majority of cases; however, with several surgeons operating on this group there were some minor variations. Three incisions were used in 6 cases. In these cases the long curved first incision was not continuous and the peroneal tendon was removed from its bed

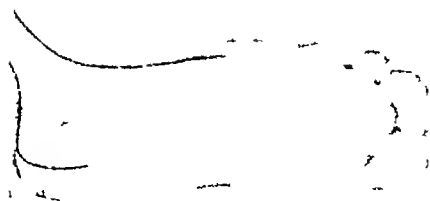


Fig. 1. Skin incision and subcutaneous dissection area of leg undermined.

by subcutaneous dissection. In one instance the peroneus brevis tendon was cut and sutured into the tendon of the peroneus longus to give added muscle power. In another case the tibialis anterior as well as the peroneus brevis was transplanted, the former being sutured into the tendo achillis, the latter into the peroneus longus. In 3 cases long leg casts were applied and in 1 instance no cast at all was used.

Immobilization in plaster was maintained for about 3 weeks at the end of which time the cast was removed, the wound was inspected and the stitches were removed. Active exercise was then begun in physical therapy. At the end of 5 to 6 weeks the patients were allowed to be up and walking with a heel elevated to correspond to the amount of plantar flexion which remained. This heel was gradually lowered over a period of several months until it was the usual or needed height. Physical therapy and muscle re-education were continued until the patients left the hospital, usually about 2 months after operation.

POSTOPERATIVE COMPLICATIONS

In only 3 of the 13 cases in which operation was performed did primary healing of the incision occur. There is a persistent tendency for the edges of the central portion of the undermined area to slough. In all cases the incision eventually healed. The average healing period was 2 to 3 months, the longest healing period was 6 months. In 1 case pinch grafts were used to hasten healing. In the later cases great care was taken to separate

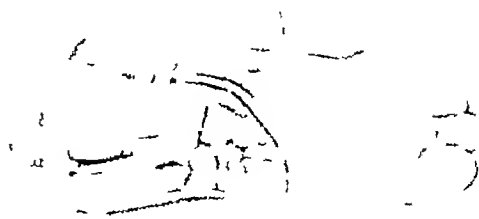


Fig. 2. Groove in calcaneus for reception of peroneus longus tendon.

the incisions as far as possible and to carry out the subcutaneous tunneling as close to the bone as possible. The circulation in the intervening tissue then appeared to be more adequate than when the earlier procedure was used and better healing was obtained.

RESULTS

While strength and function in transplanted or translocated tendons and muscles are sometimes difficult to estimate, in the cases here considered it is possible to make some very definite conclusions. The results were classified in 5 groups. When the deformity persists the result obviously is *poor*. With the deformity corrected but muscle power poor, only a *fair* result can be recorded. When walking power is present with some "push off" the result is considered *good*. If the patient is able to stand on the toes of both feet the result is considered to be *very good* and when he is able to stand alone upon the toes of the foot on which operation has been performed an *excellent* result has been attained.

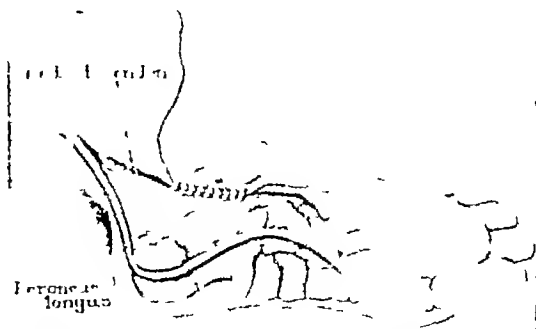


Fig. 3. Tendon mobilized from its bed and transferred to prepared groove. Closure of peroneal retinaculum.



Fig. 4. Patient sustaining entire weight on foot on which operation was performed.

The greatest improvement in the strength of the transposed muscle takes place from about the 3d to the 6th month after operation.

In this small series there were 3 poor results, 2 fair results, 4 good results, 3 very good re-

sults and 1 excellent result (Fig. 4). In summarizing the results of operation there were 8 satisfactory end results and 5 cases in which there was little if any improvement.

The peroneal tendon was re-explored in 4 instances. In 2 cases it was loose and in the 2d it was frayed out. In all cases the tendon was tightened and in 2 the strength of the peroneus brevis was added by transplanting it onto the calcaneus. The results remained poor and subsequently an anterior bone block operation was performed on one patient.

Two of the poor results can be definitely attributed to the transposition of a peroneus longus tendon which was too weak to be of value in its new function. One tendon became frayed out from what was probably an improperly prepared bed. No definite cause could be determined in the other 2 unsatisfactory results.

CONCLUSIONS

Transposition of the peroneus longus tendon in calcaneal deformities of the foot has produced satisfactory results in a sufficient number of cases to warrant a continuation of its use. The best results have been obtained when the operation was done on patients who had slight remaining power in the gastrocnemius muscle and fair or better power in the transposed peroneal muscle. It is our opinion that the results in this procedure are strikingly better than if the peroneal tendon is cut and transplanted into the tendo achillis or calcaneus.

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FRACTURES OF THE NECK OF THE FEMUR

An Analysis of 157 Intracapsular and Extracapsular Fractures

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THIS study analyzes the management of 157 consecutive fractures of the neck and intertrochanteric region of the femur seen on the Fracture Service of the Third (New York University) Division of Bellevue Hospital from January 1, 1941, to June 30, 1943. It is our contention that immediate internal fixation enhances the ability of feeble, undernourished patients to survive, permits their ambulation in bed, reduces the incidence of potential complications, and allows early ambulation with crutches.

INTRACAPSULAR FRACTURES

There is sufficient evidence that the older methods of treatment were unsatisfactory. The plaster spica, Russell's traction, well leg traction, and other conservative procedures "chained elderly people to the mattress" and subjected them to potential complications which endangered their lives with no assurance that union would follow (Fig. 1, a, b, c, d, e).

Changes in position for feeding, for use of the bed pan, or adjusting bed linen, accentuate the pain of an inadequately immobilized fracture and make sedation inevitable. Spontaneous motion in bed is restricted. Despite good nursing care, usually inadequate in charity hospitals, incontinence, cystitis, decubitus ulcers, sepsis, thrombophlebitis and hypostatic pneumonia beset the bedridden patient, and all militate against his surviving with a fracture which may ultimately heal.

The voluminous literature concerning the results of internal fixation for fractures of the hip attests to the general acceptance of this method of treatment as the procedure of choice. The question of subjecting the feeble patient to the tremendous risk of the opera-

tion has caused many surgeons to wait until the condition of the patient improves. In our experience many of these patients have continued to fail, and we have operated upon them when pain and impending complications from confinement to bed dominated the clinical picture. Most of our patients who died were over 70 years of age, undernourished, and poor risks, and were in the group initially treated by traction.

It has been our impression that those patients who were treated with internal pin fixation immediately or very shortly after admission had a better chance of surviving and had a smoother course than those in whom operation was delayed to wait for the condition of the patient to improve. While the operating room is being prepared efforts are made to combat shock and dehydration.

Attention must be centered primarily on saving the patient's life, and it is our thesis that by immediate internal fixation of all fractures about the hip the mortality from these injuries has been reduced and the incidence of union has greatly increased.

It may be argued that frail and feeble patients might not stand the operative procedure. Granting that such a possibility may arise, the fact remains that they may have difficulty surviving the complications of the conservative methods of treatment. While we admit that our mortality has been high, we do not attribute this to the method of treatment but rather to the pre-existing complications and delayed surgery as most of the deaths occurred in the group which had preliminary treatment with traction. Contributing factors have been the desire to obtain perfect reduction and proper placement of the transfixion nail, this occasionally required further manipulation, replacement of incorrectly placed guide wires and waiting for the development of the roentgenograms, all of which was time consuming.

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To lessen the shock and the ordeal of the operation in the feeble patient in whom on admission there is about 75 per cent alignment of the fragments or in whom the attempt to realign the fragments has resulted in only a 75 per cent reduction we recommend transfixion without further manipulation. The delay due to further manipulation and to the necessity of reinserting guide wires and awaiting development of the roentgenograms is all cumulative. Such delay adds to the shock and ordeal of the operation and may have a telling effect on the patient's life. While the roentgenograms will not reveal the soundest observance of the principles of mechanical fixation nevertheless a sound therapeutic procedure has been carried out if the transfixion and fixation is sufficiently firm to permit the patient to be out of bed in a few days.

We do not wish to offer any compromise in reduction or proper placement of the transfixion nail in the younger age group or well preserved individuals. We are well aware of the inherent dangers of taking this position. But in the feeble, frail individuals or those afflicted with serious medical problems, careful evaluation should be made of the ability of the patient to withstand any protracted surgical procedure. Under these circumstances some compromise in reduction is permissible.

It is logical that immediate transfixion helps to preserve the meager blood supply from the ligamentum teres and the torn capsular vessels. When thus adequately immobilized, there should be no rotation or shearing of the fracture surfaces or extension of damage to the visceral capsule which would jeopardize the effort to re-establish an arterial anastomosis and cement the fracture surfaces. The more proximal the fracture line the more urgent the need of immediate transfixion and the more desirable the need of the closest approximation of the fragments to normal.

A majority of surgeons use the Smith Peter or three flanged nail. Others favor various modifications of skeletal fixation such as Henderson's lag screw, Moore pins and the like. Our experience has been limited chiefly to the use of the cannulated three flanged nail. Those who use the three flanged nail feel that it meets the criteria of rigid fixation expressed by

Watson Jones, i.e. that (1) the flanges prevent rotary movement, (2) the length prevents angulatory movement, (3) there is a minimum of bone displacement and (4) there is a maximum of surface contact.

The immediate and final results of internal fixation are therefore contingent first on the ability of the patient to surmount the ordeal of the operative procedure and become ambulatory; second the ability of the disrupted blood supply to re-establish its continuity and cement the fractured surfaces; and third the maintenance of the fragments rigidly in position until there is roentgenographic evidence of union—a factor depending on the second contingent.

Operative procedure of internal fixation. In patients of younger age and those well preserved, a general or spinal anesthesia is used. In the aged and feeble 30 cubic centimeters of 1 per cent procaine hydrochloride is introduced anteriorly into the joint and 30 cubic centimeters along the line of incision. Premedication with morphine should be used with caution in old people. Small doses of 1/6 grain may bring the patient to the operating room in marked respiratory depression. The decision as to immediate preoperative sedation is left to the anesthetist in the operating room.

In most instances reduction has been accomplished by the Leadbetter maneuver which is indicated in most cases by the heel palm test. The fractured extremity is then securely fixed on the traction table in a position of 30 to 35 degrees internal rotation to maintain the neck on a horizontal plane and abducted with barely enough traction to maintain the limb in position. The other leg is maintained in a comparable position of abduction and slightly lower to allow sufficient room for placing the x-ray tube for taking the lateral roentgenograms.

After reduction is obtained an effort is made to establish bony landmarks to aid in the accurate insertion of the guide wire and pin. We eliminate complicated gadgets for directing the insertion of the nail. We follow the simple expedient of placing a Michel clip over the middle of the inguinal ligament as suggested by Moore. Another skin clip is added 1 inch below and 1/2 inch lateral to the femoral



Fig 1 a, T K, 54 years of age, had an intracapsular fracture on January 17, 1941 b, Satisfactory restoration of fragments in bilateral Russell traction with abduction c, Absorption of the neck from shearing and rotation result

ing from the constant though limited motion in bed d and e, Treated with internal fixation 3 months after admission to hospital This patient regained complete function, followed 3 years

artery Both clips form opaque targets and are utilized as focal "sights" for gauging the direction of the guide pins

The distortion of the skin clips on the roentgenograms should be avoided so as to obtain the fullest advantage of these focal points in expediting the operation This distortion can be prevented (1) by keeping the patient's pelvis absolutely horizontal on the tunnelled cassette holder, (2) by centering the x-ray tube over the neck of the femur and parallel to the hip and pelvis, (3) by placing the skin clip in the obese on the overhanging skin at a site corresponding to the midpoint of the inguinal ligament

The time of the operative procedure depends on the rapidity with which we can take and develop the plates We do not use the fluoroscope for checking our reduction and have tried to make 3 sets of x-ray plates serve our purpose the first to check reduction and locate the skin clips in relation to the head, the second to locate the position of the guide pins, and the third to check the position of the three flanged nail

The use of two machines has simplified our procedure since once the machines are properly located the operative field can be draped without being disturbed by subsequent manipulations of the machine for check roentgenograms

Operation While the first set of roentgenograms are being developed, a burr hole, somewhat smaller in diameter than the Smith Petersen nail, is drilled 1 inch below the protruding ridge of the lower end of the great

trochanter as suggested by Watson-Jones We have found, that by beveling the lower outer and upper inner borders of the burr hole with a small osteotome, the guide wires are not deflected by the overhanging ridges of the cortex

Having determined the relation of the skin clips to the head of the femur, two calibrated guide wires are inserted in the direction of the middle and inner quadrant of the head In the insertion of the wire through the medulla of the neck, the operator should be able to push the wire in without drilling until the wire hits the head If it fails to enter easily, it is striking the cortex along the wall of the neck and should be redirected

In high subcapital fractures the guide wire is drilled for a short distance into the acetabulum as recommended by Henderson This step anchors the head, prevents its rotation when the oncoming nail crosses the fracture site, and the nail is less apt to impinge on the guide wire

As indicated by the second series of roentgenograms, the better of the two guide wires is used for the insertion of the nail Preferably, the nail should traverse the fracture line in the most vertical position so that the superimposed body weight will be directed through, rather than across, the fracture line To determine whether the wire is encroaching on the pin it is sufficient occasionally to rotate the wire without extracting it The drapes remain on the patient until the final roentgenograms are approved

It is our opinion that the three series of roentgenograms are essential to the success of

the operation. The elimination of any one series of roentgenograms may jeopardize the ultimate outcome.

The insertion of a nail without the aid of guide wires may save time but if the nail is misdirected and requires reinsertion, no time is saved and there is added risk of damage to the cancellous bone and its blood supply.

With the developing facilities near the operating room and with the aid of a rapidly acting developer the waiting time can be appreciably lessened.

Postoperative care and follow-up. A light plaster boot to the knee with a horizontal board reinforced with plaster behind the heel is applied in the operating room. This insures against outward rotation of the leg and displacement of the nail. We do not permit patients to be turned on the uninjured side. We partially attribute to this procedure the displacement of the nail from 5 high subcapital fractures and therefore caution against it. Quadriceps exercises are encouraged and the patient is allowed out of bed in a week.

Weight bearing is deferred until union is roentgenographically evident. However few of our patients use their crutches properly. It is significant that the patients with the greater angles began bearing weight sooner complain less and dispense earlier with their crutches without any untoward effect.

ANALYSIS OF RESULTS OF THE TREATMENT OF INTRACAPSULAR FRACTURES

There were 57 intracapsula fractures. Fifty three were treated by internal fixation 37 with a Smith-Petersen nail, 5 with a Smith-Petersen nail and Hawley bar and by Moore pins for a spontaneous fracture following radiation for carcinoma of the cervix. One patient was treated by external fixation with Roger Anderson half pin. Three patients were treated by Russell traction.

The three hips treated by Russell traction were impacted abduction fractures. Only enough weight was applied to keep the leg from rotating outward. The position of the fragments did not change during the 3 months the patients remained under observation.

Twenty-eight of the 54 patients were operated upon as soon after admission as facilities

could be arranged 16 others within 4 days within 21 days, and the remaining 3 were operated upon one on the 25th day, another at the end of 2 months and the third at the end of 4 months.

The patient who was treated by external fixation with half pins developed infection at the site of insertion of a distal pin. The patient was followed for 11 months. The fracture united and he is back at work (Fig. 2 a, b, c, d).

Mortality. Of the 52 cases treated with the Smith-Petersen nail 5 died (9.6 per cent). They were 68, 79, 84, 75 and 70 years of age. Their nutritional status on admission was poor. They were first treated in traction for 12, 3, 2, 37 and 8 days, respectively. They continued to do poorly and were operated upon under local anesthesia in the presence of some complication. They died on the 5th, 5th, 7th, 103rd and 21st day respectively after their operation.

Extrusion of the nail from the proximal fragment. In 5 patients the nail slipped out of the proximal fragment. They were reinserted. This occurred on the 4th, 1th, 12th, 13th, and 42nd day. We attribute this to (1) promiscuous turning the patient on the uninjured side in bed and (2) failure of the nail to engage the proximal fragment adequately.

Follow-up. Forty nine of the 54 patients (91 per cent) were followed 15 for 1 to 3 years, 8 from 7 to 2 months, and 7 from 4 to 6 months. Nineteen were observed for less than 3 months. Some of those followed for short periods were sent to institutions from which it would be inexpedient to have them return.

One year after nailing a low transcervical fracture a hiatus, 5 to 4 inch developed. The nail straddled the fragments without any change in the position of the head and shaft. A fibular graft which broke weeks later while the hip was immobilized in a double spica, did serve to establish vascular channels in the proximal fragment and by its osteogenesis has served to fill the hiatus.

There has been 2 cases of aseptic necrosis of the head. Both occurred in high subcapital fractures. In one the nail extruded from the head and was reinserted while in the other there was a gradual shortening of the neck and

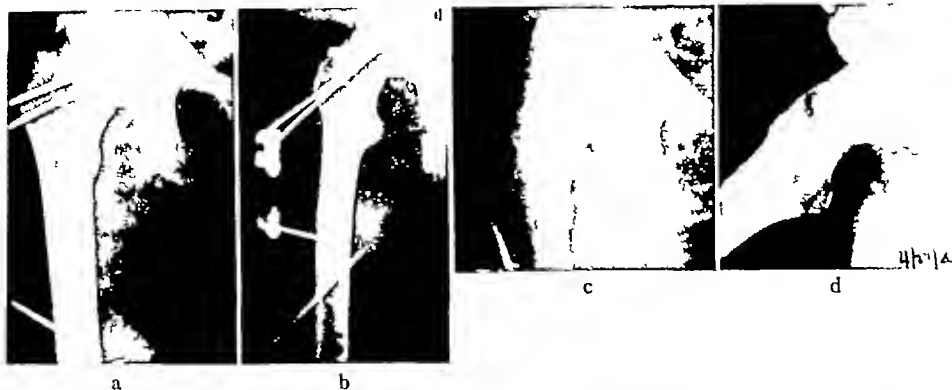


Fig 2 a, b, A.S., January 25, 1943, 57 years of age, intracapsular fracture transfixed with Roger Anderson half pins. Note penetration of the opposite cortex by the distal pin. c, d, Pins were removed 2 months after insertion. Patient has been followed for 10 months and has fully regained the function of his hip.

subsequent necrosis of the head in a woman who had a kidney removed for carcinoma.

While subjective complaints suggestive of traumatic arthritis have occasionally been encountered, they have not been substantiated by roentgenographic evidence.

While it is too early to evaluate our end-results, we believe that in many cases the procedure has been a life saving measure and that the results have been satisfactory.

EXTRACAPSULAR (INTERTROCHANTERIC) FRACTURES

In our experience the intertrochanteric fracture has had a higher morbidity and mortality than the intracapsular fractures. In our series there are 100 patients, (64 per cent) with extracapsular injuries as compared with 57 (36 per cent) with intracapsular fractures. Our mortality for extracapsular injuries was 22 per cent compared with 8.7 per cent for the intracapsular fractures.

It is an erroneous impression that the intertrochanteric fracture is not as serious as the intracapsular injury. The patients are subjected to more shock and to the same potential complications as in the intracapsular injuries. There is frequently extensive comminution and more marked external rotation of the shaft because the shaft is not restricted by the capsular attachment which is proximal to the fracture line. There also is a greater extravasation of blood, more marked deformity and

considerably more pain and restriction of motion. Even in lieu of these facts the profession has assumed that intertrochanteric fractures are not serious problems because union takes place frequently with or without treatment.

While the pertinent problems in the treatment of intertrochanteric fractures are the same as in intracapsular fractures, namely (1) can we avoid the potential complications which follow hip fractures, (2) can a method of treatment be employed which offers the patient a reasonable chance to survive with a useful hip—the failure to correct the disturbed relation of the intertrochanteric fragments in the debilitated and aged is of secondary importance.

Bilateral Russell traction for intertrochanteric fractures. While it is generally acknowledged that the diminished angle of the neck and external rotation in intertrochanteric fractures can be corrected by unilateral or bilateral Russell traction, it does not provide rigid immobilization of the fracture site. However, the limited motion at the hip in traction does not prevent union. It is recognized that traction in moderate abduction must be uniform and sustained uninterruptedly by having (1) the foot of the bed elevated, (2) the back rest maintained in a lowered position, and (3) the spreader to which the leg traction is attached prevented, even momentarily, from resting against the foot of the bed. If attention to these details can be assured, and the surgeon



Fig. 3. a, G.P., 53 years of age, sustained an intertrochanteric fracture in September, 1943. Was in the hospital 3 years in 6 months; refused treatment and altered around with crutches. Pseudoarthrosis. b, Nine months after the insertion of Smith-Petersen nail and Hawley bar and immobilization in plaster. Union and function has been almost completely regained.

believes that the patient will stand the prolonged stay in bed without serious mishap; then this procedure is the simplest form of treatment that will insure the patient a good leg with firm union and in most cases a normal angle. This treatment requires between 6 to 8 weeks before sufficient union is present to permit the patient out of bed on crutches without weight bearing.

Assuming that the patient does survive any of the nonoperative methods of treatment we cannot minimize the fact that he has had a prolonged and frequently a stormy stay in bed and that not infrequently some disability results, i.e. a *coxa vara* deformity, shortening, external rotation and occasionally nonunion.

The incidence of nonunion is small because the extensive fracture surfaces are (1) usually impacted so as to limit rotary motion and (2) they are so adequately supplied with blood from the bone and the muscular attachments that union invariably results. Nevertheless nonunion may supervene if the mobility of the fragments is not restricted. Too early ambulation even with the aid of crutches will not restrict muscular contracture and upward displacement of the distal fragment. A *coxa vara* deformity, persistent outward rotation or a pseudoarthrosis may result.

A striking incidence of nonunion of an intertrochanteric fracture with a well established pseudoarthrosis was observed in an unco-operative patient 53 years of age. Within

7 months he repeatedly interrupted his treatment in several institutions. It was not until the fragments were immobilized with a Smith-Petersen nail and a Hawley bar in a plaster space that adequate fixation and union was obtained. A plaster cast was used for 6 months to insure immobility in this old injury. Nine months after the operation there is some roentgenographic evidence of union (Fig. 3 a, b, c).

Transfixion of intertrochanteric fractures. One can readily understand why surgeons have been reluctant to transfix intertrochanteric fractures by means of a three flanged nail. Such a nail driven through a comminuted fracture not infrequently causes a dispersion of the fragments. The grip of the nail in the shaft below the trochanter is much too short and inadequate. A Smith-Petersen nail or unsupported shaft pins of any type will not adequately immobilize this type of fracture. The superimposed body weight and contraction of the thigh muscles will also distort the insecurely fixed fragments so that any conceivable type of displacement may supervene. This explains the faulty mechanics involved in depending on this type of fixation alone. By fixing a Hawley bar to the Smith-Petersen nail and to the shaft of the femur a reasonably firm and adequate fixation could be assured. In 5 cases the screws holding the nail and bar became loose resulting in a change in the position of the fragments and necessitating last

ening or reinsertion of the screw. We used the Moore pins in 7 cases, and in none were we able to retain the position of the fragments. We have had no experience with the Thornton, Jewett, Casberg, or Thatcher devices. We have used Roger Anderson's external pin fixation as recommended by Anderson, McKibbin, and Burgess. Because of seepage and untoward results reported elsewhere in this paper we have discontinued using external pin fixation for fractures about the hip.

We believe that the blade plate devised by Moore and Blount (Fig 4), will obviate the difficulties which we have had with the Smith-Petersen nail or Hawley bar. It is now our procedure of choice for fractures about the intertrochanteric region. By the use of this principle of fixation, the debilitated patient with an extracapsular fracture is offered the same advantages of treatment as the patient with an intracapsular fracture.

ANALYSIS OF THE RESULTS IN INTERTROCHANTERIC FRACTURES

There were 27 of the 100 patients who were treated by Russell traction alone, with 2 deaths (7.4 per cent). The 2 who died were 67 and 83 years of age and death occurred on the 17th and 27th days, respectively. Of the 25 who survived, their stay in the hospital was from 2 to 4 months. Five have been followed from 1 to 3 years, 9 from 4 to 12 months, and 11 for less than 3 months. There were 34 patients who were treated by Russell traction from 3 to 15 days and then operated upon. They are included under the analysis of patients treated by internal fixation.

Of the 73 patients operated upon, 68 were treated by internal fixation and 5 by external fixation. The 5 patients treated by external fixation died. Many were 70 years of age and more. While there was no immediate reaction to the operation, infection around the pin sites contributed to their death. Of the 68 patients treated by internal fixation, 34 had been previously treated by Russell traction for 3 to 15 days. Nine of these patients died (13 per cent).

In 7, Moore pins were used, 3 of the patients died. They were 78, 82, and 92 years of age and were operated upon under local anes-

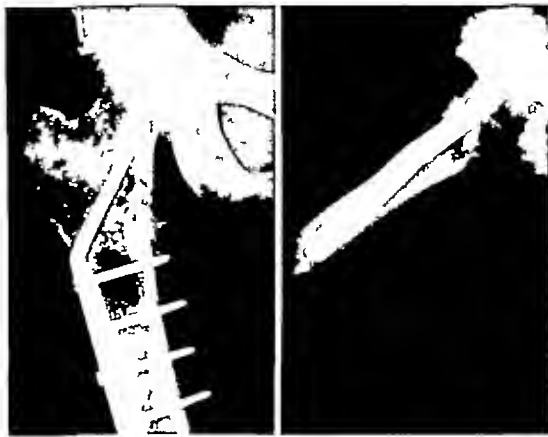


Fig 4 a, left, and b, Mrs. E. Mc., 73 years of age, had a comminuted intertrochanteric fracture. Treated with a single angle Moore-Blount blade plate with no external fixation.

thesia on the 17th, 7th, and 6th day, respectively. They were all in precarious condition. Of the 4 others, a coxa vara resulted in 3. The object of the operation was to make it possible for the patients to be moved in bed without pain.

Of the 61 patients who were treated with a Smith-Petersen nail with or without the Hawley bar, 12 died, a mortality of 19.6 per cent, and a 12 per cent mortality for the entire group. Four wounds were infected and responded to treatment. In 5, the screws holding the bar to the nail became loose and resulted in a change in the position of the fragments. They were reappplied. Not all of the comminuted fragments were perfectly replaced, but the fixation did hold the major fragments in position with the exception of the 5 cases in which the screws loosened. The displacement of the avulsed lesser trochanter frequently remained unchanged. This was followed with an enormous proliferation of new bone which was contiguous with the shaft and not infrequently accounted for considerable pain.

The periods of observation for the 53 patients who survived their internal fixation is as follows: 1 for 2½ years, 10 for 1 to 2 years, 10 for 7 to 12 months, 9 for 4 to 6 months, and 23 for less than 3 months. Some were homeless and social problems and had to be placed in institutions, from which it would be inexpedient to have them return.

EXTERNAL PIN FIXATION

So much has recently been said about successful external pin fixation in the treatment of fractures that a note of caution must be sounded in the application of this procedure to fractures of the hip. Our experience with external pin fixation has been limited to 3 intra capsular and 5 extracapsular fractures. In our hands the complications encountered have been sufficiently serious to merit critical review.

Infection developed at the site of pin insertions in all of the 6 cases. Five patients died. The infections undoubtedly were contributing factors to their demise. If other surgeons have experienced the same disastrous consequences, we have not found any mention of it in the literature. Of the 5 patients who died, 3 was over 60 years, and 4 over 70. They were all in poor physical condition.

The procedure was undertaken because of the many advantages which the authors attributed to its use. Primarily they claimed that rigid fixation could be obtained by external pin fixation without an incision and thus eliminate an operative wound with damage to the soft tissue, impairment of the blood supply and bony structures. It was also claimed that this method of treatment would appreciably lessen the shock which attends an intra articular or extra articular operation; that the procedure was much simpler than an open operation and that it obviated the use of a plaster spica or traction and thus permitted the earlier use of crutches and appreciably shortened the period of hospitalization.

No difficulty was encountered in properly transfixing these fractures after they had been reduced. There was practically no shock or reaction to this procedure and it was simpler and less time consuming than an open operation.

The friction of the soft tissues of the thigh against the pins when the patient sank in the mattress or raised himself on a bed pan or turned in bed resulted in an inflammatory reaction about the pins which subsequently became infected. The first site to become infected was usually the uppermost muscular and fleshy part of the thigh. Some of the patients undoubtedly fingered the dressings at

the sites of pin emergence. Every effort was made to keep the wound meticulously clean. The nursing care became a serious problem. The head of the pins dug into and tore the sheets. The patients were not comfortable. They were reluctant to move and were apprehensive.

The patient (A 5) who survived, 57 years of age. He had transverse fracture (Lusk) local anesthesia the fragment were realized by the Lead better maneuver. A collodion dressing as applied over the pin sites. The patient allowed out of bed on the 9th day. One of the pins in the shaft of the femur projected slightly beyond the opposite cortex. An abscess soon appeared at the site of insertion of this pin. Within few days tender area of induration as palpable on the inner side of the thigh. It was then kept in bed. With movement the swelling increased in size and as persistent tenderness. The pins were removed months after their insertion. The pins in the shaft were loose—on withdrawal, 3 ounces of pus was evacuated. The pins in the neck of the femur were found to be held rigidly. Within few days after the removal of the pins the discharge diminished and the wound healed. Eleven months later the fracture, as noted on the patient discarded his crutches (Fig. 1, b c d).

In our hands external pin fixation did not simplify the management of fractures of the neck of the femur. Other than expediting the procedure of immediate transfusion and minimizing the amount of trauma in the process of fixation this method had no advantage over internal fixation. The nursing care was increased; the patients were apprehensive and refused to be ambulatory because of the pain in the region of the pin sites. There was a constant dread of infection because of the exudate which resulted from the friction caused by the movement of the soft tissues against the pins. Under these circumstances the surgeon could not discharge the patient from the hospital with the apparatus for fear of infection. To have transfixed the protruding pins adequately to the soft tissue it would have been necessary to incorporate them in a plaster spica cast which would immobilize the pelvis and both hips. This would be reverting back to the procedure of confining the patient to bed with its potential dangers.

We believe that external fixation for fractures of the hip and intertrochanteric region to be a hazardous procedure and should be reserved for those experienced and familiar with its use.

We do not believe it should replace internal fixation for fractures of the hip

CONCLUSIONS

The treatment of choice for the intracapsular fractures in the aged and feeble is the immediate insertion of a Smith-Petersen cannulated 3 flanged nail or similar device

The treatment of choice for the intertrochanteric fractures in the aged is the immediate insertion of a device incorporating the principle of a Smith-Petersen nail and Hawley bar, preferably a Moore-Blount blade plate

For intertrochanteric fractures in the younger age group bilateral Russell traction suspension has given very satisfactory results, and we see no reason at present to change our opinion

External pin fixation should not replace internal fixation for fractures of the hip or intertrochanteric region Other than expediting the procedure of transfexion and minimizing the immediate trauma, it has none of the advantages of internal fixation It is an extremely hazardous procedure and should be restricted to those who have had experience and are familiar with its technique

It is our conclusion that the patients who are in poor physical condition on admission have a better chance of survival if they are operated upon immediately rather than waiting to see if their general condition improves We disagree with the selection of survivals policy in which all patients are treated conservatively for a few days and then the operation is decided upon only for those whom it is expected will survive

Immediate operation permits early ambulation in bed without pain, reduced incidence of potential complications, and allows early ambulation with crutches

The use of local anesthesia, focal skin clips, and guide wires, and the three sets of indispensable roentgenograms, to determine (1) the accuracy of reduction and location of the skin clip in relation to the head of the femur, (2) the position of the guide wires, and (3) the position of the nail, will enhance the ability of the surgeon to expedite the proper insertion of the transfexion device

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INDUCTION EXAMINATION FOR INGUINAL HERNIA

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A LARGE and concentrated experience as a part time surgical examiner in a southern New York induction district, including the largest induction station in the United States, has given me the opportunity of examining many thousands of men, for hernia. This experience has offered an unusual chance to learn many important details in hernia examination together with evaluation of those conditions which simulate or mask hernia or offer problems in differential diagnosis. It is hoped that the observations in this paper may be helpful to others, even if some facts which are generally known are re-emphasized.

Men who have hernias are not acceptable to the armed forces. This article will deal only with examination for inguinal hernia. No distinction will be made between the direct and the indirect. For practical purposes, hernia is diagnosed when a sac can be made to protrude beyond an external ring by increased intra-abdominal pressure produced by any technique.

Surgeons usually develop individual methods for the examination for hernia. Consultation among surgical examiners at the induction station has been encouraged so that the establishment of the presence or absence of hernia in a doubtful case is made only after an examination by several surgeons.

The pressure of work at an induction station becomes very great, so that it is important to develop system in the examinations. The men strip completely, line up in groups of 6 and inquiry is made whether any man complains of a hernia. A group request is made for each candidate to turn his head to the right, place a hand over his mouth, and cough or strain when instructed to do so.

Stance of the examinee. The man should face the examiner and stand up straight and with the feet flat on the ground and about one foot apart. The examination is frequently uncomfortable, ticklish, or psychically disagreeable to the candidate, with resulting lack of co-operation. This may be evidenced by laughter, rigidity

flexion of the knees, standing on one foot or the toes, pulling away or turning the body. Reassurance and gentle examination usually correct these conditions.

TECHNIQUE OF THE EXAMINATION

Inspection may show swelling in the inguinal or scrotal regions. Coughing or straining may elicit a bulge but this does not necessarily mean the presence of hernia. If a sizeable bulge disappears when the man lies down the surgeon presumes that a mass has been reduced which is probably hernial in origin.

Palpation should be gentle at all times. Too much stress has been laid on "impulse on coughing" alone as diagnostic of hernia. Such an impulse may occur with or without invagination of the scrotum and without the presence of a hernial sac. But an impulse which transmits to the examining finger a circumscribed soft, compressible mass indicates the presence of a sac. Frequently a hernial sac does not have an impulse either because of the nature of its contents or because of surrounding adhesions. The three middle fingers placed over the external ring may feel a definite impulse or trickle or thrill when the examinee coughs or strains. These signs are presumptive but not positive evidence of hernia. Supplementary examination is made with the ungloved tactile surface of the index finger on which the nail has been cut short. The left finger is used for the left side and the right for the right side. The dependent part of the scrotum is invaginated up to the pubic spine but not into the external ring. The pubic spine should be felt at all times as an identifying landmark. A small and elusive sac may be demonstrated by the preliminary jumping, coughing, straining, or squatting of the examinee, or by finger pressure downward over the inguinal canal. One of these methods may help to elicit the sac when all the others fail. Frequently coughing alone does not bring down a sac. In such an instance, it is surprising how often one of the other methods will demonstrate the sac. Straining especially is helpful in revealing a hernia. The value of straining to demonstrate the presence of a hernia has been so impressive that its routine adoption is recommended. Straining produces maximum muscle play and is associated with a more prolonged intra-abdominal pressure than is coughing.

From the Armed Forces Induction Station, Grand Central Palace, New York.

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large gonadial, or it may be the end result of an inflammatory condition of the cord and testis. The thickened cord can be pushed aside with the examining finger which should in every case first locate the pubic spine.

5. Proptotoneal fat can be felt as a fat tab within the inguinal canal. It is usually situated medially. It may be movable and there is no enlargement or expansile impulse when one coughs.

6. Hydrocele of the cord or tunica vaginalis is circumscribed elastic or very tense, and such a swelling does not reduce into the peritoneal cavity when it is squeezed or when one lies down. It usually transilluminates.

7. Split superficial fascia often creates the impression of a very large external ring. Coughing or straining may force a rounded mass through the hiatus in the superficial fascia. This mass is usually muscle and it must not be mistaken for a hernial sac. Proper palpation of the pubic spine by the examiner running the finger medial to the cord helps to locate the true external ring.

8. Muscle bulge in the inguinal region is usually very apparent on inspection. It is caused by a weak or attenuated conjoint tendon or internal and external oblique. The external ring may be relaxed or tight but a hernial sac cannot be demonstrated.

9. A mobile or undescended testis. A normally situated testis may temporarily be dislocated up

into the inguinal canal by a strong cremaster reflex. This gives rise to a soft mass in the inguinal region. A pubic or inguinal undescended testis produces a similar mass. It must not be confused with a hernial sac even though the testis blocks the external ring. A testis is smooth, elliptical, quite tender and it has a solid consistency.

THE LOCATION OF THE SAC WITH RELATION TO THE CORD

Although the usual position of the sac of an indirect inguinal hernia is mesial and slightly posterior to the cord, the sac has been found in every position around the clock. It is frequently so lateral that it is missed by casual routine examination.

SUMMARY

Observations have been made on the examination and diagnosis of inguinal hernia based on large and concentrated experience among selectees in the largest induction station in the United States. Many thousands of men were examined. This experience has served to demonstrate pitfalls in diagnosis, even in well trained and careful hands. These pitfalls have been enumerated. Various helpful techniques for examination have been discussed. Conditions which may be confused with or hinder the examination for inguinal hernia have been evaluated and suggestions have been made for differential diagnosis.

A MESENTERIC POUCH HERNIA SIMULATING PARADUODENAL HERNIA

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INTRA-ABDOMINAL hernias are of such rarity that they often escape consideration in the differential diagnosis of acute or chronic intestinal obstruction, or recurrent slight digestive symptoms. However, since an intra-abdominal hernia may possibly be responsible for such symptoms and, in view of the interesting clinical characteristics of a case which was tentatively diagnosed before operation, it seems worth while to report it.

A twenty seven year old sergeant was admitted to Hoff General Hospital on November 17, 1942, with the chief complaint of severe abdominal pain of 2 hours' duration. The family history was of no significance. The past medical history was essentially negative except for a history of frequent attacks of asthma between the ages of 5 and 14 years.

In August, 1942, the patient was hospitalized in an Army hospital for a period of 5 days for a very severe attack of generalized abdominal pain that came on suddenly after a bowel movement. There was no history of radiation of the pain, no nausea or vomiting, and, after 30 minutes, the pain gradually subsided. Three weeks later a similar severe attack occurred which lasted 10 minutes, but which was followed by a feeling of heaviness in the lower abdomen that persisted until the onset of the present attack. This attack likewise came on suddenly. The patient stated that the pain was constant and severe although at times it became worse. It was confined mostly to the lower mid abdomen. Again there was no nausea or vomiting or radiation of the pain although there was some complaint of a lower lumbar backache. No history of diarrhea or of blood or mucus in the stools was elicited in connection with any of the attacks. There were no urinary symptoms.

When seen on November 17, 1942 approximately 2 hours after the onset of pain, the patient was observed to be a well developed and nourished soldier of medium frame who was lying in bed apparently suffering from considerable abdominal pain. The temperature was 98.6 degrees F, the pulse regular and 84 beats to the minute, and the blood pressure was systolic 150 and diastolic 90. The general examination was essentially negative except for a moderate degree of facial acne and the abdominal findings as follows. There was considerable abdominal distention and on palpation moderate generalized tenderness was present which was more marked just below the umbilicus. There was no rigidity or rebound tenderness. No palpable masses or evidence of a fluid wave could be found. On auscultation, peristalsis was found to be hyperactive.

The blood count taken on admission showed 13,400 leucocytes per cubic millimeter with 90 per cent neutrophils. The urinalysis was essentially negative.

With these clinical findings a period of observation was decided upon and the tentative diagnosis was that of a

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possible volvulus due to the dramatic, abrupt, severe onset which characterized each attack. An enema was given to the patient, without results. The severe pain continued for approximately 12 hours during which time there was no temperature elevation, no nausea or vomiting, and the abdominal physical findings did not change. Following this there was a gradual improvement objectively and subjectively, and 24 hours after the onset of the attack the blood count showed 11,150 leucocytes per cubic millimeter with 75 per cent neutrophils. On November 22, 1942, it was possible to proceed with appropriate roentgenological studies of the gastrointestinal tract and one of us (A. J. P.) and Captain Robert G. Freeman carried out these examinations. On giving the patient barium by mouth a normal stomach and duodenum were observed. However, interval films taken at approximately 30 minute periods for 6 hours showed the small intestines to be coiled in a well defined circular mass suggesting the possibility of an intra abdominal hernia, probably paraduodenal, from the roentgenological standpoint (Fig. 1). A barium enema showed no abnormalities.

With the patient's history and the x ray findings a tentative diagnosis of paraduodenal hernia was made and surgery was advised.

On December 14, 1942, spinal anesthesia being used, a left rectus incision was made, and when the abdominal cavity was opened and the omentum and transverse colon were elevated a large, round, thin walled sac about 8 inches in diameter presented itself in the midline below the transverse mesocolon (Fig. 2).

The sac appeared comparatively avascular and coils of small intestine could be clearly seen within it. On exploration the colon was observed to be in its normal position and about 3 feet of the terminal ileum was in the free abdominal cavity. On elevation of the sac it was found to be lying free in the abdomen except for its attachment near the duodenojejunal juncture. On retracting the sac to the right, the duodenojejunal juncture as well as the mouth of the sac could be seen (Fig. 3). An abnormally broad and thickened duodenojejunal fold was present extending from the anterolateral surface of the upper 3 inches of the jejunum to the posterior parietal peritoneum to the left of the jejunum and serving to bind down the proximal 3 inches of the jejunum. Directly beneath the lower horizontal margin of this fold was the mouth of the hernia with the jejunum entering it, after making a very short loop, and with the ileum leaving it.

The duodenojejunal fold was severed just lateral to the jejunum and, by gentle traction on the ileum, the sac emptied itself readily. On insertion of the index finger into the mouth of the sac the opening was found to course through the mesentery of this relatively immobile loop of jejunum and on insertion of the finger fully it presented itself within the sac to the median side of this loop. The opening through the mesentery was approximately 4 centimeters in diameter, and it was observed that the neck of the sac was below and free from the duodenum and anterior to the mesenteric vessels which were not involved in the sac wall (Fig. 4). The fundus of the sac was opened and it was

wound to consist of 1. layers of bladed out peritoneum, thus proving conclusively that the walls of the sac represent pouching in the mesentery of the proximal jejunum. The mesentery to the small intestine as other meso normal.

The sac was then everted through the opening in the mesentery, the excess portion excised, and the mesentery reconstructed, completely obliterating the sac. The wound was then closed in the usual manner.

The patient had an uneventful convalescence and returned to general military duty March 9, 1911.

ETIOLOGY

In 1786 Neuhauer described the first recorded case of duodenal hernia although it was not until 1837 when the work of Treitz appeared that the subject of retroperitoneal hernia really became existent. Treitz gave a good description of the fossae about the duodenojejunal juncture, stated their probable origin, and was of the opinion that such hernias occur in fossae that are normal but by no means always present.

In a classical study of the subject written in 1899 Moynihan described 9 "duodenal fossae" in the vicinity of the junction of the duodenum and jejunum, some of which are frequently found while others are very rare. He described right and left duodenal hernias and expressed the belief that an increase in intra-abdominal pressure started the formation of a hernia provided the proper fossa was present and a loop of small intestine became engaged in the fossa.

He assembled 57 cases of so called left duodenal hernia from the literature and was of the opinion that they arose from the paraduodenal fossae or fossae of Landert which always has the inferior mesenteric vein, and at times the left colic artery in the anterior fold of the fossa. He found the following characteristics invariably present with

left duodenal hernia: (1) the inferior mesenteric vein and usually the left colic artery are present in the neck of the sac; (2) the hernia projects itself to the left toward the descending mesocolon, or toward and into the transverse mesocolon, or both; (3) the hernia contents has two layers of peritoneum anteriorly and one layer posteriorly.

Regarding right duodenal hernias, of which he collected 14 cases, Moynihan was of the opinion that they usually developed from the mesenterico-parietal fossa (fossa of Waldeyer) or the para-jejunal fossa. The mesenterico-parietal fossa was first described by Waldeyer and Moynihan states that its most usual position is in the first part of the mesojejunum, directly behind the superior mesenteric vessels and immediately below the duodenum. To quote Moynihan: "The fossa has its orifice looking to the left, its blind extremity to the right and downward. In front it is bounded

by the superior mesenteric artery and behind by the lumbar vertebrae. The peritoneum of the left leaf of the mesentery lines the fossa, that of the right covers the blind end and is then continued directly into the posterior parietal peritoneum.

Moynihan considered the para-jejunal fossa as being practically the same as the mesenterico-parietal fossa except that the first one-half to 4 inches of the jejunum is adherent to the posterior abdominal wall. Of the 14 cases of right duodenal hernia found in the literature by Moynihan, 7 had the adherent jejunum. Broesike originally described the para-jejunal fossa, found that on lifting up the first free portion of the jejunum a fossa could be seen behind and to the right of it bounded by a sharp peritoneal fold. A finger introduced into the fossa progressed between the mesentery and the posterior parietal peritoneum. Moynihan found several features invariably present in right duodenal hernias: (1) at first in all cases the sac occupies the right half of the abdominal cavity lying behind the ascending and transverse mesocolon; (2) the orifice is behind and to the left of the sac on the lumbar vertebrae; (3) the superior mesenteric artery or a continuation of it, i.e. the ileocolic artery lies in the anterior margin of the sac.

In 1920 Andrews dissented from the then prevalent opinion that small fossae about the duodenojejunal juncture are the starting point of these hernias. He presented evidence to support his thesis that duodenal hernia is a congenital anomaly due to imprisonment of the small intestine beneath the mesentery of the developing colon. If rotation of the umbilical loop is not carried to completion, he stated that a right duodenal hernia would be produced. To quote: "The caecum then would not be superior to the small intestines and as it grew to the right the small bowel would be caught in its mesentery and finally when its mesentery became adherent to the right posterior abdominal wall, the imprisonment would be complete. The superior mesenteric and ileocolic artery would lie in the free edge of the neck of the sac. Andrews regarded left duodenal hernia merely as a more pronounced degree of the same process. To quote Andrews again: "Now let us suppose that no rotation of the loop occurs, or perhaps there is a little in the wrong direction. The caecum would then be to the right of the midline in the lower abdomen. The colon runs straight to the rectum. As it gains in length, it forms a loop and when the caecum seeks its normal primitive position in the left upper quadrant, the small bowel is caught beneath the mesentery of the descending colon. The inferior

mesenteric artery would then lie in the free edge of the sac neck and the vein would lie above, thus making the vascular arch of Treitz, which has been noted in most of the hernias." This conception has been accepted by many authors.

In 1935 Callander, Rusk and Nemir reported a case of so called left duodenal hernia. In the embryological discussion they brought out convincing evidence that this type of large hernia is not a result of incomplete or malrotation but rather the result of invagination of an area of the descending mesocolon medial to the ascending branch of the left colic artery and inferior mesenteric vein by the jejunioileum while the descending colon is mobile and has not as yet fused with the primitive posterior parietal peritoneum. From the embryological and anatomical standpoints they were of the opinion that the name of this type of hernia should be changed to "hernia into the descending mesocolon." They further mentioned right duodenal hernia and suggested that it be called "hernia behind the ascending mesocolon."

In the case reported here there was no evidence of incomplete or malrotation, and outside of the hernia itself the only abnormal finding was a broadened and thickened duodenojejunal fold. As previously mentioned in the description of the findings, the sac consisted of two thinned-out layers of peritoneum and was entirely free in the abdomen except for its "pedicle" near the duodenojejunal juncture. Furthermore, although the orifice of the sac was situated to the left behind the proximal jejunum, the superior mesenteric vessels were entirely behind the neck of the sac. Therefore, the qualifications for a right paraduodenal hernia are not met, and it must be considered to be a mesenteric pouch hernia arising from the mesentery to the proximal jejunum.

Embryologically¹ it is believed that this hernia developed as a result of a preternaturally long prearterial mesentery in the region of the proximal jejunum. At the completion of the second stage of rotation it is logical to conclude that one or more loops of small intestine became engaged in a pouch formed by the preternaturally abundant prearterial mesentery to the proximal jejunum and became incarcerated as a result of early fusion of the upper jejunum as represented by the abnormally broad and thickened duodenojejunal fold found at the time of surgery. Then as a result of growth in length and size of the small intestine the hernia enlarged.



Fig 1 Anteroposterior and lateral roentgenograms taken 1 hour after barium by mouth, showing the small intestines coiled in a well defined circular mass.

SYMPTOMS

Mesenteric pouch hernias are reported much less frequently than paraduodenal hernias. However, as the hernia reported here had its origin high in the mesentery to the small intestine in the paraduodenal region and exhibited the same symptoms as might be expected of a paraduodenal hernia, it seems fitting to include this case with paraduodenal hernia in a general discussion of symptoms.

The hernia described here gave a very suggestive history of a temporary volvulus on 3 different occasions. In the literature there are cases reported in which repeated bouts of intestinal obstruction occurred over a period of years before surgical intervention was carried out or in which the first attack of obstruction necessitated immediate surgery. Other cases have been reported with vague, slight gastrointestinal distress. However, the majority of the reported cases were found either at autopsy or upon abdominal surgical intervention for some other condition with no known past history of gastrointestinal distress.

In all but a small minority of the reported cases the herniation of the small intestine has been total or subtotal and, although the proportion is smaller than we would expect, a soft, palpable tumor has been found in some cases. These cases have usually been misdiagnosed as ovarian, pancreatic, or mesenteric cysts. Andrews has reported a case in which a large palpable mass appeared only at times. As here noted no mass was palpable in our case.

If present, such a mass may be found to be more in the superior, middle, right or left ab-

¹We are indebted to Doctors C. Latimer Callander and John B. de C. M. Saunders for their helpfulness in the embryological explanation of the hernia reported here.

ound consist of two layers of thinned out peritoneum, thus proving conclusively that the walls of the sac represented pouching in the mesentery of the proximal jejunum. The mesentery to the small intestine was otherwise normal.

The sac was then everted through the opening in the mesentery, the excess portion excised, and the mesentery reconstructed, completely obliterating the sac. The wound was then closed in the usual manner.

The patient had an uneventful convalescence and returned to general military duty March 9, 1913.

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In 1920 Andrews dissented from the then prevalent opinion that small fossae about the duodenojejunal juncture are the starting point of these hernias. He presented evidence to support his thesis that duodenal hernia is congenital anomaly due to imprisonment of the small intestine beneath the mesentery of the developing colon. If rotation of the midclinal loop is not carried to completion, he stated that a right duodenal hernia would be produced. To quote "The caecum then would not be superior to the small intestines and, as it grew to the right the small bowel would be caught in its mesentery and finally when its mesentery became adherent to the right posterior abdominal wall, the imprisonment would be complete. The superior mesenteric and ileocolic artery would lie in the free edge of the neck of the sac." Andrews regarded left duodenal hernia merely as a more pronounced degree of the same process. To quote Andrews again, "Now let us suppose that no rotation of the loop occurs, or perhaps there is a little in the wrong direction. The caecum could then lie to the right of the midline in the lower abdomen. The colon runs straight to the rectum. As it gains in length, it forms a loop, and when the caecum seeks its normal primitive position in the left upper quadrant, the small bowel is caught beneath the mesentery of the descending colon. The inferior

diffuse pattern is to be anticipated with sharper angulations and segmentations of the involved loops. Palpation, normal progress of the meal, and change in position of the loops in decubitus films should eliminate a short mesentery. Various pelvic masses may displace the small bowel upward, but the lower margin of the barium filled loops will be convexly deformed. Eaker lists such conditions as a full bladder, distended large bowel, uterus, pelvic tumor, or an unusual amount of fat.

Presented with the unusual finding of a smoothly outlined, clumped small bowel pattern, and with confirmatory decrease in mobility and motility, the diagnosis of a hernia in the region of the duodenojejunal juncture should be suggested. Only by complete so called "small intestinal" studies can the proper conclusion be obtained.

TREATMENT

The treatment of hernias occurring about the duodenojejunal juncture is surgical. In recent years as a result of the earlier recognition and better understanding of congenital anomalies, the mortality rate, although still high, has been improved a great deal. Obviously the operation would be more easily accomplished and attended with less risk if carried out electively rather than as an emergency procedure in the presence of an obstruction.

From an operative standpoint the procedure may be simple, as in the case reported here, or very difficult. In some postmortem cases, in which the hernia was discovered as an incidental finding and in which there was no known history of gastrointestinal distress, it has been found impossible to reduce the hernia surgically without causing irreparable damage. This has also been found true in a few of the operative cases reported and has been due to dense adhesions about the mouth of the sac, a small nondilatable opening of a left paraduodenal hernia, or the matting together of the incarcerated small intestine by fine adhesions. In the case of a left paraduodenal hernia the inferior mesenteric vein and usually the left colic artery are present in the anterior portion of the neck of the sac and the former is usually close to the margin and courses medially in such a way that it may preclude making an incision in the neck of the sac. In a right paraduodenal hernia one is more fortunate. Because of the relationship of the vital structures, the neck of the sac can usually be enlarged by incision, if this is necessary.

In the case reported here, after reduction of the small intestine, the sac of the mesenteric pouch hernia was excised and the mesentery was recon-

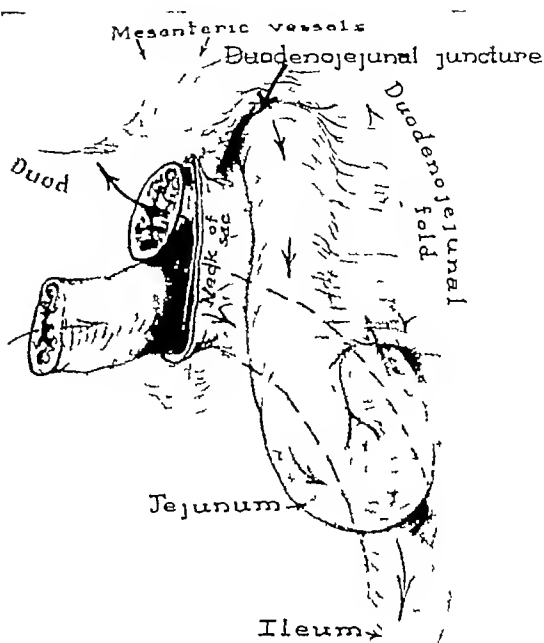


Fig 4 Diagrammatic drawing to show the posterior relationship of the mesenteric vessels to the neck of the hernia sac.

structed. However, with the usual right or left paraduodenal hernia, it is obviously not possible to excise the sac, and closure of its neck has proved satisfactory.

If obstruction is present and it is impossible to reduce the hernia, a small opening in the fundus of the sac should be made in an avascular area, a Witzel type of enterostomy carried out, and the opening in the sac closed tightly around the tube. If the patient is operated upon electively and it is found that it is impossible to reduce the hernia, one's judgment as to the danger of future obstruction would undoubtedly guide the procedure. Thus, with no previous gastrointestinal history, it is our opinion that the hernia should not be disturbed. However, if attacks of obstruction have occurred, a lateral enteroanastomosis would be indicated, provided enough ileum is present in the free abdominal cavity to carry out the procedure through a small opening in an avascular portion of the fundus of the sac. Following this it would, of course, be important to close the sac just proximal to the anastomosis. If no loop of ileum is available it is conceivable that it might be possible to do an ileocolostomy, although the risk of the procedure would be greater.



Fig. 2. Appearance of hernia after the abdomen was opened through left rectus fascium and the omentum and transverse colon were elevated.



Fig. 3. Upon the elevation and retraction of the hernia sac to the right, the hernial opening is seen with the abnormally broad and somewhat thickened duodenojejunal fold.

domen depending upon the type of anomalous development that is responsible for its formation. Percussion should give resonant note and on auscultation gurgling peristalsis may be heard.

ROENTGENOGRAPHY

Hernias occurring near the duodenojejunal juncture have very infrequently been diagnosed before operation. It is quite probable that Kummer in 1917 first visualized such process, after finding hernia during surgery and then studying roentgenograms of the barium filled loops after operation. Taylor, Case and Upson, and Exner subsequently recognized paraduodenal hernias before operation. Alexander reports 3 roentgen "impressions" without information as to operative confirmation. A complete summary of the literature is admirably provided by Exner.

From the findings of these writers, and the entire consistent observations in our case it is apparent that an accurate diagnosis is obtainable roentgenographically. There are two essential factors, namely: that the possibility of encountering such hernia be remembered and that an adequate roentgenographic study be completed. Such a study includes interval films and fluoroscopy for a variable period of from 6 to 48 hours

after barium orally. Lateral films and studies in the upright position contribute greatly to the sum of information obtainable.

The case here reported admirably emphasizes the characteristic findings. There was primary clumping of small bowel loops as if in a sac (Fig. 1) and these could not be separated or displaced by palpation. Their relationships remained essentially unchanged upon change of position of the patient. Lateral upright films demonstrated this pocketing with marked clarity (Fig. 6). There was a definite absence of small bowel loops in the pelvis and deep flanks. With such a gathering of the greater portion of the small bowel in the sac, intestinal motility was decreased and the barium meal progressed more slowly than usual.

Case and Upson stated that whenever the duodenum goes directly to the right and thence to the jejunum about the normal swing to the left, paraduodenal hernia should be suspected. Although not true in our case the mass may displace the stomach or colon. Manual pressure may be transmitted as a fluid wave.

Roentgenographically the confusing conditions include peritoneal adhesions and congenitally short mesentery (Golden). In the former more

REPAIR OF AN AVULSED SCROTUM

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REPAIR of injuries to the scrotum and penis, resulting usually from industrial accidents, is not a common problem, but when the necessity for such repair does arise a satisfactory solution is of the utmost desirability. These injuries and their sequelae are most disturbing to the patient and present to the surgeon a reconstruction problem which demands patience, persistence, and understanding.

Owens, in summarizing the reports which have appeared in the literature on penile and scrotal repair, states that there have been only 13 reports of instances of avulsion of both penile and scrotal skin, and a total of 34 reports of loss of the skin of either the penis or scrotum. Gibbs was the first to report (in 1855) on the complete destruction of the penile and scrotal skin and one other report appeared in 1881. These 2 were the only reports on this subject which appeared in the medical literature prior to 1900. The increase in the number of such reports since 1900 may be due to the fact that the increasing use of machinery has been responsible for an increasing number of such accidents, as Owens points out.

Up to the present, the method most frequently employed for covering denuded testes has been to bury them in pockets formed by undermining the skin and subcutaneous tissue on the thighs. This method has been described by Cottle and modifications of the method by Wood, Robertson, and Owens.

In the case reported by Cottle the entire scrotum and left testicle were torn off as well as all of the skin and fascia of the penis. The method of repair was as follows. An external urethrotomy was performed and a catheter was inserted. A wide area of skin together with the superficial fascia was dissected free from the inner aspect of the right thigh, thus preparing a pocket for the remaining denuded testis and the spermatic cord. A tunnel into which the penis could be placed was then prepared by lifting up the skin and superficial fascia over Poupart's ligament, and an opening was cut at the distal end of the tunnel and sutured to the collar of foreskin. After a period of 5 weeks, healing was nearly completed and the patient was able to urinate without difficulty. It was also possible for erection to occur. A plastic operation to free the penis was then performed in two stages. In the first stage, a flap of skin and

superficial fascia was freed below the penis and sutured around it, a broad pedicle being left to maintain the flap's blood supply. In the second stage, 2 months later, this pedicle was severed. The result was a completely covered penis.

In the case reported by Wood the patient had lost the entire scrotum, the left testis, and the skin of the penis. The remaining testis and cord were covered by means of skin flaps cut free at Poupart's ligament and extending 3 inches below. The free ends of these flaps were brought together and sutured. The testis was placed underneath the flaps and they were secured at the upper and lower borders. The penis was covered by means of numerous small skin grafts. The end-result was a satisfactorily covered penis and a nonpendulous covered testis.

Owens reported the case of a man who had lost all the skin from the penis and scrotum as the result of an accident which occurred while the patient was working with a tractor. Since the testes were freely movable and could be widely separated, the skin and subcutaneous fat along the medial aspect of each thigh was dissected free and small pockets were formed between the skin and underlying fat and the fascia. The testes were placed in these pockets and the top of each pocket was closed. The penis was covered by means of a skin graft which was taken from the inner surface of the right arm. This procedure afforded satisfactory covering of both the penis and the testes. From the cosmetic point of view,

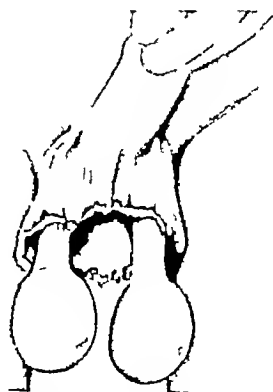


Fig. 1. Extent of injury. scrotum avulsed, testes exposed, skin of penis intact.

SUMMARY AND CONCLUSIONS

1. A mesenteric pouch hernia occurring in a soldier with a history of three attacks suggestive of volvulus is described. The preoperative diagnosis based on the roentgenographic findings was probable paraduodenal hernia.

2. Because of the origin of this hernia near the duodenojejunal juncture it is discussed with paraduodenal hernias from the standpoint of etiology, symptomatology, roentgenography and treatment.

3. While many of these rare hernias are entirely asymptomatic, they may cause acute or chronic intestinal obstruction or recurrent slight digestive symptoms and should always be considered as a possibility in the differential diagnosis.

4. If immediate surgery is not mandatory and the patient can be seen in an interval free of acute obstructive symptoms, roentgenographic studies by the so called "small bowel" technique are indicated. Thus, a correct preoperative diagnosis is to be anticipated.

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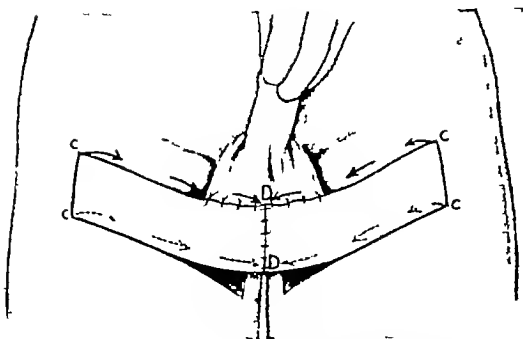
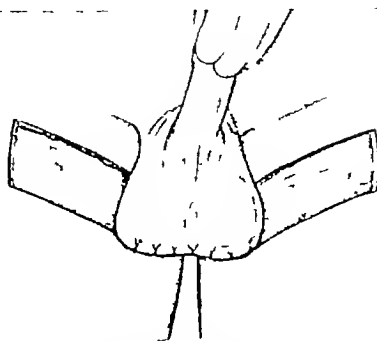


Fig 5 a, left Repair, stage 3 united flaps freed by lateral incisions, C, connecting upper and lower incisions made in stage 1, cut ends sutured behind the testes in the midline,



D, upper posterior border of flaps sutured to skin of scrotal remnant at perineal scrotal junction b, right, formation of closed sac by suturing of lower free borders

quirements and employed for the repair of partial destruction of the penis, loss of one testis, part of the scrotum, and a portion of the penile urethra, was recently described by me. In this earlier case, a skin flap from the thigh was used to cover the remaining (right) testis and the scrotal defects. A tube was constructed from the skin of the thigh and sutured into the penile defect as a connecting link between the two remaining portions of the penile urethra. In the present case, the circumstances are as follows:

CASE REPORT

In October, 1938, a 33 year old factory worker was brought into the hospital on account of a scrotal injury inflicted when his clothing was caught by a rotating wheel. (This was the 4th case of scrotal avulsion to come to our attention in the past 25 years.) The injury consisted of an avulsion of the scrotum with complete denudation of the testes. The skin of the penis was left intact (Fig 1).

The reparative process was instituted with careful debridement of the traumatized area and cleansing with soap and water alone. In the first stage of the reparative process, an incision was made through the skin and subcutaneous tissue just below and parallel to Poupart's ligament, on both thighs. A second incision was made, on both sides well below and parallel to the first incision. The skin and subcutaneous fat between the two parallel incisions on each thigh was dissected free from the underlying deep fascia to form pockets. A layer of vaseline gauze was placed on the floor of the pocket, and each testis was then placed in the pocket of the corresponding thigh on the layer of vaseline gauze (Fig 2). Vascularization between the tunica vaginalis of the testis and the overlying flap could then take place, but not between the testis and the underlying fascial tissues.

Two weeks later the second stage was performed. At this time, an incision was made on the medial aspect of each thigh connecting the upper and lower incisions made in the first stage (Fig 3). The free ends of the two flaps thus formed were sutured together in the midline (Fig 4a) and the upper free border was next sutured to the skin of the scrotal remnant at the base of the penis (Fig 4b). The testes were kept in approximately the same position as before.

The third stage was performed 2 weeks after the second stage. An incision was made on the outer aspect of each thigh uniting the upper and lower incisions. These cut ends were then brought together behind the testes, thus encircling them, and then sutured. The upper free border was sutured to the adjacent skin of the scrotal remnant at the perineal scrotal junction thus forming an open sac containing the testes, with the opening directed downward (Fig 5a). The next step was to close this sac by suturing the lower free borders together, thus affording a permanent, pendulous, normal appearing covering for the testes (Fig 5b).

The large granulating areas left on each thigh were covered with vaseline gauze and later successfully covered with half thickness grafts.

The patient has been followed for the past 4 years. The end result of the reparative process has been the provision of a normal appearing scrotal sac (Fig 6). The patient has a well balanced mental outlook and is happily married.

The reparative method described in this report has afforded a scrotal sac which it is difficult to differentiate from a normal scrotum. The normal scrotal responses to changes of temperature occur.



Fig 6 End result a normal appearing scrotal sac

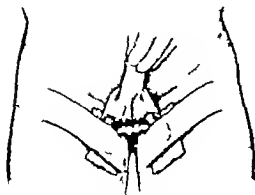


Fig. 2. Repair stage 1: formation of pockets on thighs and insertion of testes.

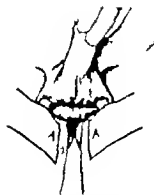


Fig. 3. Repair stage 2: formation of flaps by medial incisions, C connecting upper and lower incisions.

however, the repair was not entirely successful since a scrotum or scrotum like covering for the testes was not produced. The possibility of remedying this condition was suggested to the patient but he "was not even remotely interested" in a further operation.

Observations indicate that the imbedding of the testes in the thighs and the resultant abnormal anatomic appearance have undesirable physiological and psychological effects. The physiological disadvantages include the possibility of pain because of maintained pressure on the testes as well as tension on the cord resulting from the close quarters afforded by the pockets and their anatomical location and the possibility that maintenance of the testes at body temperature may result in sterility. In addition patients who have

undergone such repair feel definitely inferior and are loath to disrobe when other men are present. Such psychological conditioning should be avoided if it is at all possible to do so. In view of these disadvantages, neither more desirable procedure was sought and method of repair evolved which, it is believed, offers a more desirable and satisfactory solution to the problem of scrotal and penile denudation.

If an attempt to repair partially denuded penis or testis, it must be kept in mind that the procedure involves certain basic requirements which are common to the repair of any denuded surface defect, namely the injured surface must be properly debrided and cleaned and skin grafting must be performed in the usual manner. The method of repair involving these basic re-

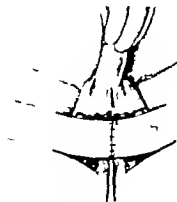


Fig. 4a. Repair stage 3: union of flaps by suturing in the midline.

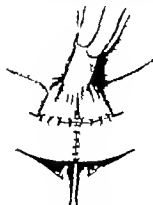


Fig. 4b. Repair stage 4: upper border of inverted flaps sutured to skin of scrotal remnant; C the base of the penis, B

A THREE PIN METHOD FOR TREATMENT OF SEVERELY COMMUNUTED FRACTURES OF OS CALCIS

GERALD G GILL, M D , Oakland, California

THE end-results of treatment of fractures of the os calcis often leave much to be desired. The common disabilities frequently seen are pain in the heel, persistent swelling and edema of the foot, flat foot, and arthritis of the subastragalar joint. The fact that many methods of treatment are in vogue at the present time indicates that no procedure is satisfactory in every case.

Boehler demonstrated the importance of restoring the tuber joint angle by instituting skeletal traction, and he improved the outcome. Nevertheless, in many cases with apparent anatomical restoration, function has been poor. In fact, certain authors recommend that triple arthrodesis should be employed routinely as soon as the initial swelling has subsided or as soon as the fracture has partially consolidated.

More recently an attempt has been made to secure perfect reduction by methods similar to Boehler's, but so to fix the fragments that motion of the ankle and subastragalar joints could be begun immediately. The rationale of this advance is based upon the thought that freer motion at the joint might prevent the development of adhesions and might also mold smaller fragments in the joint into their proper positions.

Cox has recently developed such a method.¹ He devised a very convenient traction apparatus consisting of a leather and sponge-rubber cuff which laces upon the lower leg. This device provides counter traction against which a pull can be made through a transverse pin in the os calcis. The reduction is performed with the patient upon his abdomen, the foot being in a most convenient and accessible position. The reduction is completed according to the principles laid down by Boehler after which a Steinmann pin is driven from the posterior aspect of the heel across the fracture site in a sagittal direction. The transverse pin is then removed and a slipper cast is applied incorporating the extending portion of the sagittal pin. This method has the advantage of permitting free ankle and subastragalar motion, early ambulation, and free knee motion.

In April, 1942, the author began to use Cox's method of sagittal pin fixation with some modifi-

cations. As the Cox apparatus (traction device) was not available, the Bell table was used instead. The reduction was performed with the patient upon the abdomen. It was my impression that more effective traction was obtained with the Bell table than with the Cox device. The results with the sagittal pin fixation and slipper cast were, in my opinion, superior to those following treatment with the conventional Boehler method.

In time, however, some extremely comminuted fractures were encountered. In these it was believed that reduction could not possibly be held with a single sagittal pin. For this reason, beginning in August of 1942, an alternative method of treatment was gradually developed which, as far as possible, preserves the advantages of the Cox method.

DESCRIPTION OF THE METHOD

Reductions are performed as soon as possible unless swelling is already excessive or bleb formation is advanced when first seen. After the usual skin preparation of soap and water, alcohol and ether, the patient is placed upon his abdomen on the Bell table. The Steinmann pins used are $\frac{5}{32}$ of an inch in diameter. The first pin is drilled transversely through the posterior superior angle of the os calcis. Particular care is used in placing this pin, and a hypodermic needle may be used to locate the approximate point. This location is important due to the mechanical advantage gained. A small rotating stirrup (Boehler type) is attached to this pin, and the leg is loosely suspended with a muslin bandage tied to this stirrup to one of the windlass attachments to the overhead bar. Countertraction is afforded by the weight of the leg and by tying the thigh down to the foot bar of the table with a flannel bandage. A small pillow is placed in the popliteal space to protect the popliteal vessels. Another flannel bandage is tied behind the ankle and run to the foot piece. Traction on this band allows pull against the os calcis pin to give distraction in the long axis of the os calcis. To increase the arch of the foot and the tuber angle, another flannel band is run over the dorsum of the foot and this band is attached to the same windlass as is the os calcis pin (Fig. 1).

¹Wilbur J. Cox. Description of method to be published.

in the reconstructed scrotum. There is every reason to believe that the physiological function of the testes has not been impaired, and that psychological scarring, as often evidenced by feelings of inferiority and inadequacy, has been avoided.

SUMMARY

The problems involved in repair of scrotal and penile denudation are discussed and methods previously used are briefly described.

A method resulting in restoration of a normal

appearing scrotal sac in a patient with avulsed scrotum and completely denuded testes is described.

Attention is called to the physiological and psychological benefits to the patient which result from restoration of a normal scrotal sac.

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of the hands. Particular care is taken to secure compression beneath the lateral malleolus. The use of a cast is very necessary to secure this compression. The cast is cut out to allow free ankle motion as well as behind the metatarsal heads to allow free toe motion. It should be split over the dorsum of the foot, especially in those cases reduced immediately after fracture. The extending portions of the pin through the astragalus and navicular should be cut off close to the cast. The stirrup is left attached to the pin through the os calcis, and in the ward, 3 to 5 pounds of traction should be applied. This is a most important step in the treatment, since if not done, the foot will fall into equinus which is difficult to correct. This fact was noted in the early cases. It is believed to be the result of spasm of the heel cord following the painful fracture.

From the beginning the patient is encouraged to do dorsiflexion and toe motion exercises. After 3 to 5 days, the tendency for equinus ceases and the soreness of the foot is entirely gone. Traction is then removed and the pin through the os calcis is cut off flush with the cast (Fig. 5). The patient is then allowed up on crutches and discharged from the hospital. He is carefully instructed to continue with the exercises and to elevate the foot during the day if edema occurs.

Six weeks after operation the cast and pins are removed. An elastic adhesive dressing or Unna paste boot is applied from the metatarsal heads to the upper ankle to prevent edema. Exercises are continued and in addition, the patient is instructed to begin inversion and eversion of the foot. Weight bearing is begun 8 weeks after operation. A metal arch support is worn in a heavy work shoe. The arch support is similar to any

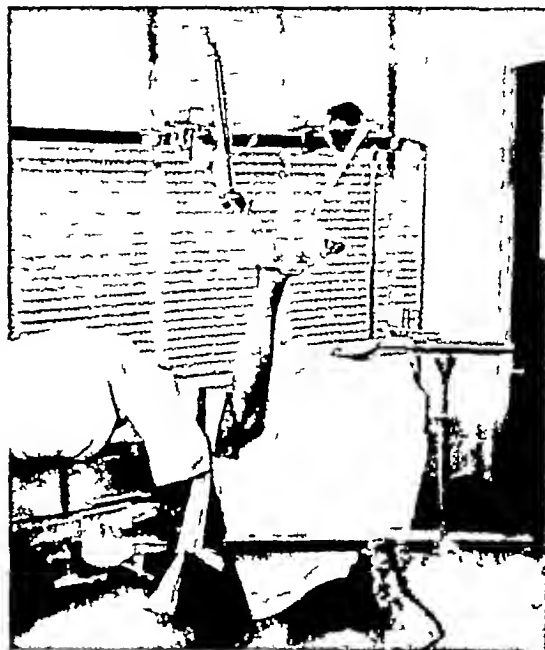


Fig. 4 The cast has been applied while traction is still being maintained.

regular support except that the heel portion is removed and replaced with sponge rubber. The exercises are continued rigorously. Contrast baths are taken twice daily to control any remaining tendency toward edema during the early weight-bearing stage.

Under this regimen excellent ankle and toe motion and very good subastragalar motion result. Many of these patients have returned to work as



Fig. 5 The completed cast after the pin through the os calcis has been cut off flush and the patient is up and about on crutches.

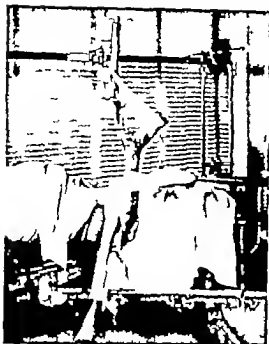


Fig. 2 Position of the patient upon the Bell table just before first x-ray films are taken to check reduction.



Fig. 3 Steinhilber pin in position with traction being maintained.

Traction is then increased upon the os calcis pin until the heel cord is very tight and the arch of the foot apparently restored. The os calcis is then compressed laterally with the Boehler clamp. Three applications are made, special care being taken to compress the bone under the lateral malleolus. It should be noted here that the Boehler clamp should be improved by adding larger blades moulded to conform to the configuration of the os calcis.

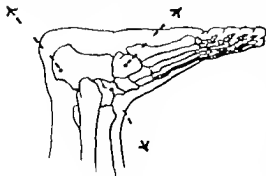


Fig. 4 Diagram to show points of pin insertion and approximate direction of pull.

Lateral and axial roentgenograms are then taken to check reduction. If it is seen that the fracture is transverse and not greatly comminuted, a Steinhilber pin is driven under fluoroscopic control in a sagittal direction across the fracture site and cut off the end extending 1 inch from the heel. The transverse pin is removed and a slipper cast is applied incorporating the sagittal pin.

If however the fracture is seen to be comminuted and not likely to be held by a single pin sagittally placed the other two transverse pins are inserted. The first pin is drilled through the neck of the astragalus from the medial side of the foot at a point just below the tip of the medial malleolus and one finger breadth anterior to it. Another pin is drilled through the cuboid from the lateral side of the foot at a point just above the base of the fifth metatarsal (Fig. 3). A rotating stirrup is then applied to this pin and it is attached to another windlass on the overhead bar. Traction is placed on this pin in an upward and anterior direction (Fig. 3).

A nonpadded cast is applied incorporating the three pins, sheet wadding being placed only around the ankle and metatarsal heads (Fig. 4). While the plaster is hardening forcible lateral pressure is made upon the os calcis with the heels

of the hands. Particular care is taken to secure compression beneath the lateral malleolus. The use of a cast is very necessary to secure this compression. The cast is cut out to allow free ankle motion as well as behind the metatarsal heads to allow free toe motion. It should be split over the dorsum of the foot, especially in those cases reduced immediately after fracture. The extending portions of the pin through the astragalus and navicular should be cut off close to the cast. The stirrup is left attached to the pin through the os calcis, and in the ward, 3 to 5 pounds of traction should be applied. This is a most important step in the treatment, since if not done, the foot will fall into equinus which is difficult to correct. This fact was noted in the early cases. It is believed to be the result of spasm of the heel cord following the painful fracture.

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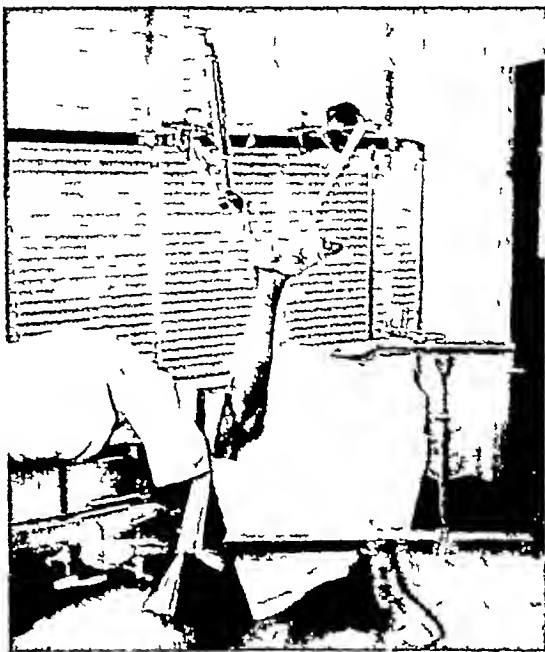


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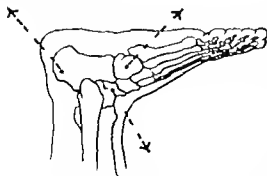


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CONTROL OF PAIN IN POST-TRAUMATIC VASCULAR DISTURBANCES

AFTER trauma, complete recovery does not always follow in reasonable time. In a large group of patients disability persists abnormally long in spite of satisfactory anatomical healing, in spite of physiotherapy and other means to obviate the remaining symptoms. The conditions being discussed are so numerous and variable it is difficult to class them under one heading. Included are causalgia, sympathalgia, Sudeck's atrophy, value pains not strictly deserving designation by any of these terms, and in addition painfully stiff joints and ischemic contractures of the Volkmann type. These conditions do have two things in common, namely, pain persisting abnormally long, and vascular disturbances. The type of pain by its very indefiniteness is more or less common to all. It may be mild, it is frequently severe. It is often unlocalized, it is deep, segmental, diffuse and usually its pattern does not con-

form to the distribution of a sensory nerve. The pain resembles that of other vascular disturbances such as Raynaud's disease and the "rest pains" of thrombo-angitis obliterans. The conditions included are not the immediate consequences of trauma, they are in that period of convalescence when the immediate reaction to trauma has since passed and healing of bone and soft tissue has occurred. The pain—for that is a constant symptom—may be disabling, but sometimes the objective evidence to support its actuality is so obscure the possibility of malingering may rightfully be entertained. In addition to these pains, however, the extremity may be colder than the opposite one, a condition detectable by the thermocouple if not by gross clinical examination. Other evidences such as edema, osteoporosis, and stiffness of joints and muscles may be more concrete evidences of vascular disturbance. Able investigators have found an increased flow of blood through the affected extremity, but have explained the disassociated diminished surface temperature by surmising a mixed vasodilatation and vasoconstriction. Whether this vascular disturbance is the cause of the pain is uncertain. However, induced vasodilatation usually has coincident dramatic relief of pain.

In 1915 Leriche performed a periarterial sympathectomy on the brachial artery for a vasomotor phenomenon associated with pain, cyanosis, and a cold extremity in a man who had had a bullet wound of the axilla. The burning pain was immediately relieved. This was a new approach to the relief of such pains. Since then, however, the rôle of the sympathetic nervous system in the posttraumatic syndrome has not been widely appreciated,

early as 12 weeks from the date of reduction. There has been a surprising lack of edema and pain in the foot. In some cases mild subastragalar pain has occurred after work for 1 to 3 months. Thus far the patients have preferred working rather than losing time for triple arthrodesis. Nevertheless, it is probable that at least 50 per cent of these patients will need triple arthrodesis in the future. It is my belief however that the results after triple arthrodesis will be better in fractures treated initially by this method than in those treated initially by other methods. The restoration of the architectural height of the os calcis will allow satisfactory performance of this operation. In addition, the excellent general condition of the foot, the good muscle tone, and the good calcification of the bone with good ankle and toe motion without swelling and edema will promise better and earlier healing and weight bearing without tenderness.

No pin infections have been encountered in fractures treated to date except those in which slough of the skin was present before treatment was instituted. In these there was some drainage

from the slough and the pins were removed early—4 weeks. Interestingly enough it should be noted that no loss of skeletal correction has followed in these instances.

CONCLUSIONS

The method of treatment described is believed by the author to offer many advantages over those now in common use. For the transverse fracture the modification of the Cox sagittal pin method is undoubtedly superior. For the badly comminuted fractures, the three-pin method should be used. It is contended that superior architectural restoration is gained. In addition, there is less decalcification of the bones of the foot, less edema, and increased ankle and foot motion. Earlier and better functional results are seen. The method is comfortable and inexpensive in that hospitalization time is reduced.

While it is admitted that many patients will later need triple arthrodesis, it is believed that the improved condition of the foot and bone will permit better function after this operation than is usually seen.

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PLANS FOR THE 1944 CLINICAL CONGRESS IN CHICAGO

AT a meeting of the Board of Regents held in Chicago on May 5 plans for the 1944 Clinical Congress of the American College of Surgeons, to be held in Chicago October 24-27, were approved. Thus the surgeons of this city will be privileged to act as hosts to a large group of their colleagues for the eighth time since the first meeting in 1910.

Under the leadership of a representative committee of Chicago fellows a clinical program is being prepared for presentation at the medical schools, affiliated teaching hospitals and other large hospitals, to include operative and nonoperative clinics, demonstrations, and exhibits conducted by the surgeons and other specialists connected with these institutions. All the special fields of surgery will be represented therein, affording the visiting surgeons an opportunity to study at first hand the latest advances in surgery as well as important experimental and research activities of Chicago institutions. The program will present a wide variety of material in the fields of general surgery, fractures and other traumas, neurosurgery, thoracic surgery, orthopedic surgery, urology, obstetrics and gynecology, ophthalmology, and otorhinolaryngology. Clinics and demonstrations at the hospitals will be held on Tuesday afternoon, October 24, and on the mornings and afternoons of the three following days.

The Congress will open at 9:30 on Tuesday morning with a general assembly in the Ballroom of the Stevens Hotel. The President of the College, Dr. W. Edward Gallie, of Toronto, will preside. Other speakers will include Dr. Irvin Abell of Louisville, Chairman of the Board of Regents, who will review the activities and accomplishments of the College during recent years. The Surgeons General of the Army, Navy, and Public Health Service will report on the accomplish-

ments of their departments during nearly three years of war.

At the Presidential Meeting and Convocation on Tuesday evening in the Ballroom of the Stevens Hotel the new officers of the College will be inaugurated and initiates of the classes of 1942, 1943, and 1944 will be received into fellowship. Dr. W. Edward Gallie will deliver the presidential address at this session and distinguished visitors from foreign countries will be introduced. At scientific meetings on Wednesday, Thursday, and Friday evenings at headquarters eminent surgeons of the United States and Canada, and possibly visiting surgeons from foreign countries, will present papers on surgical subjects of timely importance. The programs are in preparation under the direction of the Board of Regents and will be published in a later issue.

The value of panel discussions as a medium for conveying information on selected topics has been amply demonstrated at previous Congresses and sectional meetings. Programs for a series of panel discussions dealing with new aspects of military and civilian surgery will be held daily during the Congress at which eminent surgeons will collaborate in the presentation of vitally important material. Opportunity will be afforded for free discussion of the subjects from the floor by those attending the panels.

It will be recalled that an important feature of Congresses held in years just prior to the war was the "Forum on Fundamental Surgical Problems" which it is expected will be given a place in the program. The purpose of the forum is to enable younger men representing university departments of surgery to present the important results of their clinical and experimental work.

Both military and civilian surgeons will participate in the demonstrations, panel discussions,

of Medicine is the basis of the present work. Of Garrison 4, 86 entries Mr Morton has retained 3,836 and added to them 680 new references which include important contributions made in the last decade and recently published histories. Author and subject indexes have been provided. By means of brief annotations the English librarian has indicated the significance of various contributions. The references are numbered consecutively and under each

A MEDICAL BIBLIOGRAPHY, A Check List of Texts Illustrating the History of the Medical Sciences. Originally compiled by the late Fielding H. Garrison, revised with additions and annotations by Louis I. Martin. London: Grafton & Co., 1903. (28s.)

subject they are arranged in chronological order. In a volume of such relatively small size many references that might have been included have of necessity been omitted. The histories of special subjects usually found at the end of each section compensate for such omissions. This book makes

valuable in convenient form the most valuable contributions to the history of medicine and its auxiliary sciences. Offered as a starting point to something better it will be of undoubted value to librarians, bibliographers, students of the history of medicine and to research workers. WALTER H. WATKIN.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and in space permits.

TEXTBOOK OF GENERAL SURGERY. By Warren H. Cole, M.D., F.A.C.S. and Robert Elman, M.D. New York and London: D. Appleton-Century Company, 944.

SMALL COMMUNITY HOSPITALS. By Henry J. Southward, and Geddes Smith. New York: The Commonwealth Fund, 944.

OPHTHALMIC OPHTHALMOLOGY. By Hester S. Kuhn, M.D., St. Louis. The C. V. Mosby Company, 944.

PROCEDURES FOR CONCEPTION OF PROGENY OF HIGH FERTILITY. Sponsored by the National Committee

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and formal scientific sessions on fractures and other traumas. Developments in the care of injuries suffered in civilian accidents, as well as those encountered in military action, will be featured.

Besides its interest to physicians caring for civilian patients, cancer is of increasing concern to those entrusted with the care of military personnel and veterans. The developments in diagnosis and treatment since the last Clinical Congress in 1941 will be covered as comprehensively as possible in this symposium.

The general program of the Congress includes many features of special interest to those surgeons whose practice is limited to ophthalmology or otolaryngology. Operative clinics and demonstrations will be given daily at several of the hospitals. Programs for a series of clinical conferences and scientific sessions, all to be held at the headquarters hotel, are being prepared. Outstanding specialists will present papers of particular current interest and will lead the discussions. A series of selected motion pictures related to these special subjects will be exhibited.

The College is embarking upon an intensive program to stimulate the creation of more opportunities for graduate training in surgery and the surgical specialties, designed chiefly to meet the needs of returning military medical personnel who desire to resume their education which was interrupted by war service. Medical educators and chiefs of surgical staffs will discuss methods of carrying out the principles of the minimum standard of the College.

Concurrently with the Clinical Congress, the usual Hospital Standardization Conference will be held. Topics will be chosen which are of the greatest current interest to hospital administrators and other executive personnel. Among these will be post-war planning; rehabilitation, so far as its hospitalization aspects are concerned; the emergency maternity and infant care program; distribution of penicillin to civilians; re-employment of former employees upon their discharge from military service; and such other subjects as may assume importance in the coming months.

A daily presentation at headquarters of a varied program of surgical motion pictures is planned, to include the newest available films approved by the committee on medical motion pictures.

Meetings of the state and provincial Judiciary Credentials, and Executive Committees will be held on Wednesday forenoon at headquarters with addresses by the President, officers of the College, and the Regents. The annual meeting of the Governors and Fellows will be held in the Ballroom of

the Stevens Hotel on Thursday afternoon beginning at 1:30.

The hospitals of Chicago afford accommodations for a large number of visiting surgeons, but attendance at the Congress will be limited to a number that can be comfortably accommodated. Surgeons who expect to attend the Congress will therefore register in advance. Admission to clinics at the hospitals and to certain scientific sessions at headquarters will be controlled by means of tickets issued to the visiting surgeons at the registration desk.

In accordance with a resolution adopted by the Board of Regents, fellows of the College whose dues are paid to December 31, 1943, initiators of the class of 1944, and fellows in military service will not be required to pay a registration fee. For endowed junior candidates the fee is \$5.00 for surgeons who are not fellows, attending as invited guests of the College, the fee is \$10.00.

Headquarters for the Congress will be established at the Stevens Hotel which affords unusual facilities for so large a meeting as the Congress. The public rooms on the second and third floors have been reserved for scientific sessions, conferences, and panel discussions. The Technical Exhibition, together with the registration desk will be located in the large Exhibit Hall on the lower floor of the hotel where leading manufacturers of surgical instruments, sutures, dressings, pharmaceuticals, operating room equipment, x-ray apparatus and hospital equipment of all kinds, as well as publishers of medical books, will be represented in the exhibition.

Chicago has many first class hotels, several within walking distance of headquarters. Reservations for hotel accommodations should be made at the earliest possible date. The following hotels are recommended:

	Minimum rate per night	
	Single	Double
Atlantic, 116 S. Clark St.	\$ 25	\$2.50
Bowditch, 7 W. Randolph St.	3 75	5 00
Blackstone, Michigan A. at Balbo Ave.	4 00	7 00
Brynmor, 30 W. Madison St.	30	3 50
Chicagoan, 67 W. Madison St.	75	4 00
Drake, Walton Place at Michigan Ave.	00	7 00
Eastgate, 4 E. Ontario St.	75	4 00
Edgewater Beach, 1340 Sheridan Road	4 40	4 00
Harrison, 57 E. Harrison St.	00	3 00
Kauffman, 163 E. Walton Plac.	3 50	5 00
LaSalle, Madison and LaSalle Sts.	75	4 00
Medinah Club, 305 W. Michigan A.	5 00	5 00
Merrison, 70 W. Madison St.	75	4 00
Palmer House, 4 E. Monroe St.	3 45	5 50
Parkers, 9 N. Clark St.	3	3 50
St. Clair, 16 E. Ohio St.	3 00	4 50
Swiss, 207 E. Chestnut St.	4 00	6 00
Thermal, 61 W. Randolph St.	75	4 00
Stevens, 720 S. Michigan Ave.	3 75	5 00

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